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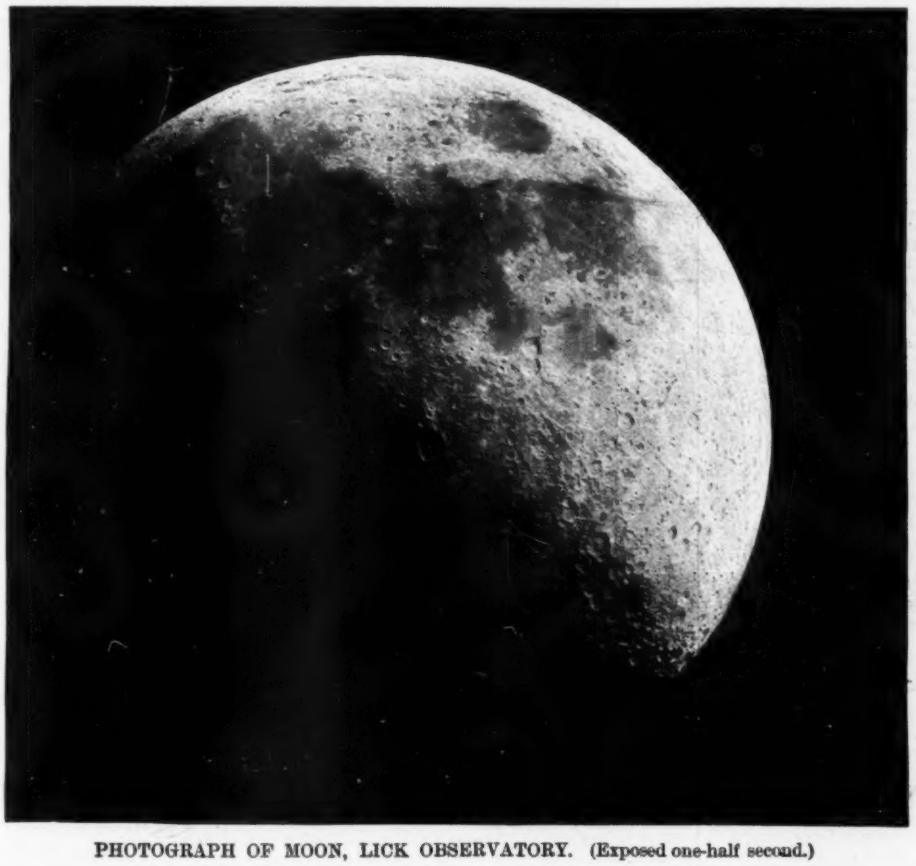
THE METHODS AND INSTRUMENTS USED IN ASTROPHOTOGRAPHY.

CELESTIAL photography, which is of comparatively recent origin, has yet a great future before it. Thanks to the perfect systems of modern mechanism, the excellent optical apparatus at our disposal and the rapid progress of photochemistry, preliminary experiments have been quickly disposed of. The first result of the improved methods was the summoning of an astronomical congress to Paris in 1887, where the then director of the Paris Observatory, Admiral Mouchez, proposed the preparation of a photographic copy of the whole firmament by the collaboration of all the eminent observatories. At the same time regulations were drawn up to insure that the work should be conducted uniformly, on similar lines by each. Only refractors, no reflectors, were to be used, a standard aperture of the objective and a standard focal length were agreed upon. As far as possible similar formulæ were to be used for emulsion of the photographic dry plates. The time of exposure was fixed at fifteen minutes.

It was calculated that such an exposure would furnish a total of 20–25 millions of fixed stars; as the number visible to the naked eye is 8,250, one can imagine what a surprising result would be obtained by the process. However, the cataloguing of these millions would supply material to fill something like 300 volumes, so that the very accuracy of the effort would make its execution impracticable. Consequently, it was at a later date resolved to make a second exposure of one minute for cataloguing purposes. The first exposure would show all stars down to those of the fourteenth magnitudes, the second those down to the eleventh, reducing the number of stars to be measured to about one million.

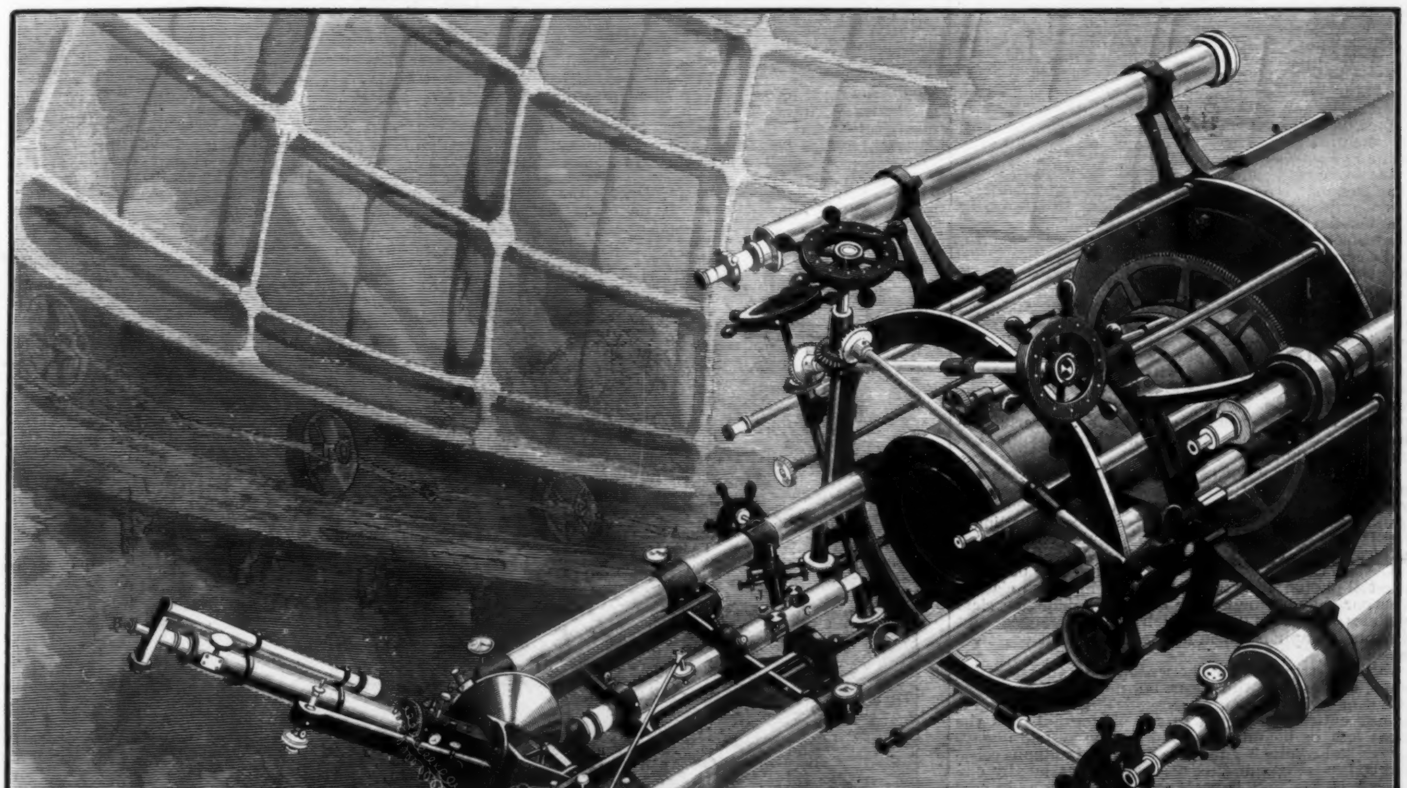


PHOTOGRAPH OF MOON, LICK OBSERVATORY. (Exposed one-half second.)

The position of all stars for the beginning of the year 1900 is to be given in the catalogue. About 25 years will be required for the completion of the calculations, the work being so distributed that a zone of the declination is assigned to each observatory taking part in it.

As regards the uniformity of the work aimed at, as mentioned above, there are of course numerous different sorts of instruments in use, which, though producing excellent results in themselves, yet render congruent working difficult, but the variety in them seems calculated rather to add to the value of the results than the contrary.

In the first place, arrangements have in many cases been made by which the refractors already in use for visual observation



EYEPIECE OF THE REFRACTOR OF THE LICK OBSERVATORY.

may be employed for astrophotographic purposes. The simplest form of such a contrivance is the attachment of a camera to the eyepiece of the telescope. In cases where this is done, the chemical focus cannot, of course, be made to coincide with the optical focus.

Photographs obtained in this way are not sharp, and consequently do not bear much magnifying. Another method consists in arranging the tube so that the photographic plate can be brought into the chemical focus. The 36 inch refractor of the Lick Observatory on Mount Hamilton, California, is constructed so that the eyepiece can be removed, and the plate holder inserted in the proper place. The idea of attaching laterally to the refractor a telescope suitable for photographic purposes is occasionally employed. But telescopes of this construction, on account of their great focal length and their small objective aperture, cover a very restricted field.

Of the instruments built specially for photographic purposes we must first mention the equatorial of Sir Howard Grubb. In this type the two tubes are intimately connected by a common envelope in their top parts only. On the whole, the usual form of parallactic mounting has been retained, but the constructor's aim was to get rid of the clumsiness inherent to the double refractors of the German type. Grubb's instrument permits of a circumpolar motion, without any sacrifice of firmness or stability.

An original instrument, which was primarily intended for visual observation only, but afterward partially reconstructed for photography is the "equatorial coudé," i. e., knee-shaped equatorial, of the National Observatory, of Paris. It was built according to the instructions of M. Loewy, the director of the observatory, M. P. Gautier taking charge of the mechanical part, the brothers P. and P. Henry providing the optical requisite. The annexed illustration is so clear that it requires but a few words of explanation. The instrument consists of two parts—tubes—which are brought into union by a large cast iron cube, the axes of the two tubes being at right angles. The eyeglass tube, which is slightly the longer, is placed parallel to the earth's axis, and its upper extremity rests in a ring which is fixed to the northern pillar. A conical projection forming a continuation of the tube on the other side of the cube provides it with another axial support on the second southerly pillar.

The object tube, which is attached to the eyeglass tube at right angles, lies in the equatorial plane, as is evident from these conditions. The tube contains a second inner tube, which ends in a cubical head. The object cylinder bears on the end diametrically opposite a tubular projection, which is, however, considerably longer than the short cone of the other tube, and which serves mainly to balance the system. The mechanism of the eyepiece head we shall not go into, on account of the many details, which do not in any way affect the principle of the whole. The cast iron objective head contains a mirror, placed at 45° to the axis. The central cube is provided with another mirror, which is so placed that it lies at an angle of 45° with each tube. The objective head, moreover, bears the objective which lies in the equatorial plane, at right angles to the earth's axis. From this arrangement it follows that a ray of light falling perpendicularly on the objective glass passes through it on the first mirror, is there reflected at a right angle on to the second mirror, whence it is again reflected in the direction of the axis of the eyepiece tube, that is, to the eyeglass itself.

As can be seen from the illustration, only the eyeglass end of the whole instrument is inclosed in the observation room, while all other parts are open, and accessible by an elliptic flight of steps. Protection for these parts is provided by a movable cover which can be rolled close to the wall, and removed when the instrument is in use.

The advantages offered by the "equatorial coudé" are very evident, not to mention the comfort permitted to the observer, whose work is infinitely facilitated by the natural position of the head. He is protected from the inclemency of the weather. And particularly in winter, owing to the open roofing of the spacious rooms in which the great refractors are lodged, the cold is in ordinary cases very much felt.

Rather crude, and seemingly far more clumsy than the double refractors of the nature of the instrument at Potsdam, is the photographic equatorial of the Vatican Observatory. The excess of rigidity of the whole system secures, it is true, a great stability, and a corresponding exactness in photographic images, but the free mobility, as found in Grubb's system, is altogether lost.

Besides refractors, reflectors are also used, and with great success, for astrophotography. Thus Isaac Roberts, the owner of the private observatory at Crownborough Hill (Sussex), worked with a 20 inch reflector, and the negatives obtained with this instrument have thrown all similar productions into the shade. Our readers may remember the excitement which the photograph of the Andromeda nebula by Mr. Roberts produced, both by its size and by showing the spiral nature of the nebula.

As a fourth group of astrophotographic instruments might be regarded those apparatus which are simply constructed after the model of a camera. When portrait lenses of short focal length and correspondingly great lucidity are used, excellent results, covering an extensive field, can be obtained.

Taking them as a whole, the accessories used for celestial photography may be divided into two classes, whether they be dioptric or catoptric. The first class includes all instruments which are so arranged that the photograph is taken in the focus of the objective lens.

In the instruments of the second class the negative is not obtained in the focus, but outside it, by means of a magnifying system of lenses. This last method is almost entirely restricted to sun photography, as the great loss in lucidity incurred by the system always causes bad results in the case of feebly luminous celestial bodies. Though this method is occasionally employed, it has only importance as a last resort in case of need. Photographs obtained outside the focus cannot be magnified to any great extent. Hence their scientific value is in many cases small, or altogether vanishing.

As regards astronomical measurements we have the option of various, preferably of three, methods. The first is measurement by polar co-ordinates. In this the photographic plate is either brought under a microscope provided with a network of threads or the microscope is fixed, and the plate is moved by a micro meter screw, which measures the distances. The measuring instrument turns round the center of a graduated circle, from which the direction of the connecting line can be read. This procedure permits of an exact measurement of the distance between any star placed

PHOTOGRAPHIC EQUATORIAL OF THE VATICAN OBSERVATORY.

temporarily in the center of the circle and the other stars, or the points of intersection of the net.

If the instrument is turned through 180°, and the measurement again taken, the placing of a fundamental star in the center is unnecessary.

The second method, that of the perpendicular co-ordinates, is similar to the one described above. In this case the plate is fixed, and the microscope is moved by two micrometer screws, which are at right angles. The measurement may be taken directly with regard to the netting, but it is desirable that the latter should be so placed as to have points of the same declination lie along one thread.

The possibility or supposition of an error in the perpendicular position of the screws requires a second measurement after the instrument has been turned over 90°, and, if necessary, additional measurements after the instrument has been turned through angles of 180° and 270°.

Less accurate, but very convenient, is the method used by Kapteyn, namely, the placing of the plate perpendicularly in front of a theodolite located at a proper distance, by means of which the stars and intersections are so measured that the readings of the arcs of the instrument give the required data for the calculation of the stars' distances.

Lastly A. Repsold & Sons, in Hamburg, have constructed a measuring apparatus which differs from the above described in this respect, that it can be used in two ways, viz., first, for the determination of distances and angles of position; secondly, to determine the perpendicular co-ordinates.

An apparatus of this description stands in the V. Kuffner Observatory, at Vienna, and is depicted in our illustration.

Having now described the chief methods of work and the kinds of instruments employed for securing astronomical negatives and then using the result for further investigation, we will remark in conclusion that Der Stein der Weisen has supplied us with some of our subject matter and illustrations. We trust that the latter will serve to make clear the descriptions of the text.

England is about to change the system of carrying the gunners of field batteries by mounting them on the off side horses instead of seating them on the limber boxes of the guns. This system was in use forty years and was condemned in consequence of the experience in the Indian mutiny.

BENT EQUATORIAL OF THE PARIS OBSERVATORY.

CURIOUS WEAPONS.

THE BOOMERANG AND ITS ORIGIN—WAR QUOITS AND KNOBKERRIES—THE BLOWPIPES OF THE DYAKS.

SAVAGES all over the world possess weapons which are curious and generally more or less effective. These peculiar instruments of offense and defense may be divided, says the London Standard, into two classes—those which are merely curious forms of ordinary weapons, representing the eccentricities of the savage mind, and those which are curious from the fact that they are constructed upon complicated scientific principles—principles of which the savages who use them cannot be expected to know anything, and which, indeed, have only been discovered by European scientists within the last couple of centuries. Perhaps the most curious of these is the boomerang. We all know about this weapon; in fact we mostly know more about its powers than the aborigines of Australia, who are the only people who use them. Among other things which we know about it is that it may be thrown at an object, will hit it, and, after having laid it low, return to its owner, like a retriever. The aboriginal Australian is not so advanced as this. The poor fellow does not know that it ought to return to him after he has killed an emu or kangaroo with the weapon; he goes and fetches it. In fact, it is only when the savage has missed the object aimed at, that the boomerang will return to him—were it to touch a leaf even, it would be sufficient to turn the course of the weapon. But how came these savages by the weapon? Did the earth-eating aborigines of Australia—a race whose idea of numbers does not extend beyond three, for they count "one, two, three, many"—invent it? Or is the boomerang but the remains of an old, long forgotten civilization—a civilization old as that of the Chinese? Nobody but the aboriginal Australian can use this weapon nowadays, but that it has been known before, and that by a race which was not only civilized, but had attained to a considerable degree of scientific knowledge, there is no room to doubt, for in Egyptian sculpture there are many unmistakable representations of it in hunting scenes. It is the same weapon exactly, curved to the same angle, curved on one side, and flat on the other, and was used in the same way. Still it requires a very imaginative mind to connect Australia and Egypt, so that the problem of how the boomerang came to be used by the Australian savage is one the solution of which must probably remain a secret for all time.

A weapon which is constructed on the principle of centrifugal force has been in use among the Indian tribes of South America from time immemorial. Denuded of superfluous aspirates, the name of this weapon sounds something like "bolero," and it consists merely of a strip of rawhide, about 10 feet long, to each end of which is attached a heavy leaden or stone ball. When the thrower wishes to use it, he grasps the thong in the middle with his finger and thumb, whirls the weights round his head two or three times, and then, with a peculiar twist, flings it at its mark in such a manner that the two balls travel parallel to each other, with the thong stretched out between them. In this way the "bolero" makes its journey through the air until it reaches the object at which it is thrown. Then the center of the strip of hide strikes the object aimed at, and the balls, continuing to move forward, but being stopped by the thong, coil round the legs or neck of the victim, in the same way as a whip lash will coil round a stick, on a blow being made at it—and so hobbles or strangles the animal until its pursuer comes to release it.

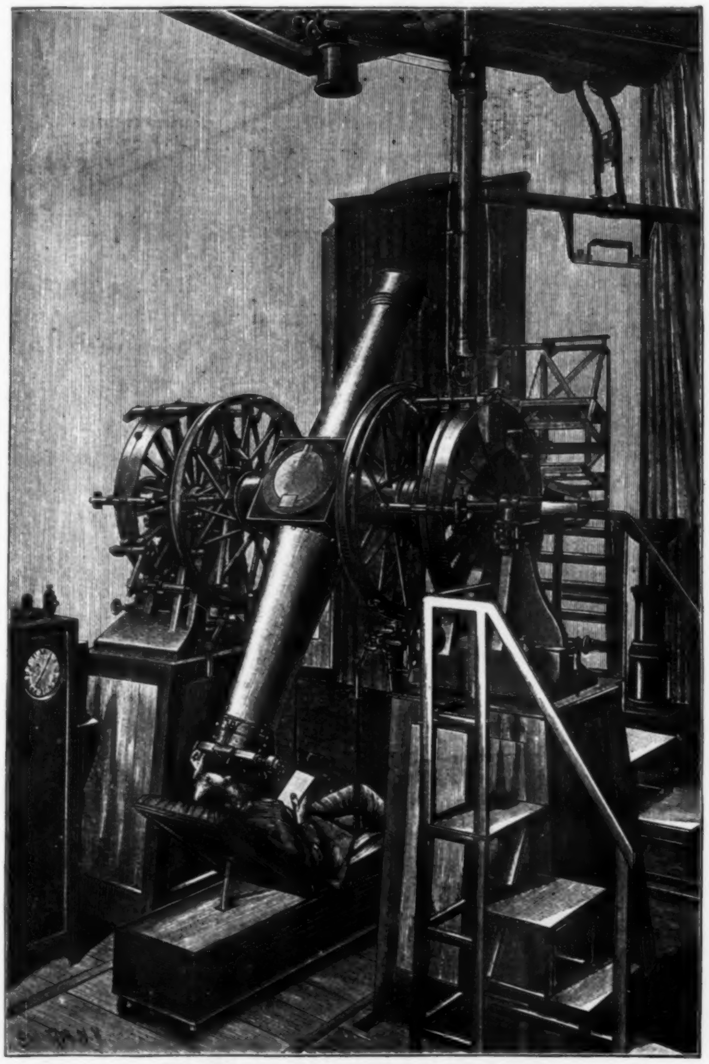
This form of "bolero" is mostly used for catching semi-wild animals on the pampas; but there is another variety of the weapon which is used for hunting and in warfare, and which is far more formidable. It is the same as that described above, only it has an addition in the shape of a third ball, which is attached to the middle of the thong by another shorter string, about a foot in length. When this is thrown, the short string ball travels in advance of the others, and strikes the animal at which the missile is aimed on the head with great force, after which the other balls wind round its neck or legs, and "make assurance double sure." On a somewhat similar principle is the knobkerrie which the Zulus and Kaffirs use. It consists of a short stick of light wood, at the end of which is a very heavy ball of wood or metal. Still, simple as this weapon may appear, it is not one to be despised by any means, for, in the hands of a skillful thrower, it becomes almost as formidable as the "bolero." A Zulu is able to throw it with wonderful accuracy up to a distance of 75 yards, and then woe betide the head with which it happens to come in contact. Should it belong to a human being, he will certainly make an abrupt exit from this world and appear in the next without precisely knowing what it was that sent him there.

In India, until quite recently, the Sikhs used a weapon which was fearfully effective at close quarters—the war quoit. It was the national weapon of that tribe, and is almost as old as the sword and spear. Even at the present day one of the crack Sikh regiments wears the quoit in the turban as part of the uniform. In size and shape these weapons were precisely similar to those with which the English game is played, only they are somewhat lighter, seldom weighing above twelve or fourteen ounces. Made of the finest steel the East could produce, the war quoits had their peripheries sharpened up to an edge as keen as that of a razor, and were occasionally beautified by being inlaid with gold, ivory, and even with precious stones. When he went into battle, the Sikh used to carry eight or ten of these missiles upon his left arm, their sharp outer edges being protected by a kind of casing made of platted grass. To throw it he first took off the protecting sheath, and whirling the quoit round his forefinger for a little while, threw it. Legends of the Sikh war say that men were decapitated by these flying quoits. This may or may not be true, but when it is considered what a nasty cut an ordinary light razor will make on occasions, it must be admitted that a razor-edged projectile weighing nearly a pound, and traveling at the rate of thirty or more yards per second, would make a dangerous wound, so that the legend of men being beheaded by them does not seem so very great an exaggeration after all.

Two kinds of blow pipes are in use among savage tribes. The first is made by the Indian tribes on the west coast of South America, but it is not a particularly formidable weapon. It varies in length from ten to fifteen feet, and is made from one of the many species of hollow canes that grow in the forests of those districts. Its ammunition is of two kinds: First, arrows tipped with poison; and, secondly, pellets of dried clay. But the greatest range of these overgrown pea shooters is seldom more than twenty-five yards, and they shoot very erratically, owing to the irregularity of the bore. This, however, is not the case with the "sumpit," the blow pipe used by the Dyaks, of the Malay Archipelago. These weapons are made of hard wood, are eight feet long, and nearly one and a half inches in diameter, and have a spear head fixed to them, so that they serve the double purpose of a spear and blow pipe. The bore is about a third of an inch, and is perfectly true throughout, while a thorn of the sago palm makes a natural arrow with a point almost as hard as iron. Feathered with pith and tipped with the deadly wourali poison, these arrowlets have an extreme range of eighty yards, and can be aimed accurately at an object fifty yards away.

A curious fact in connection with these blow pipes is that the Dyaks and Ryans who use them are unable to make them. The manufacture of "sumpits" is restricted almost exclusively to the Patakans, a race living in the central parts of Borneo, and which is very little higher in the scale of civilization than are the aborigines of Australia.

Here again arises the question, where did the Patakans get the idea from of boring a piece of hard wood, eight feet long, with the aid only of a piece of string, a knife, and some sticks? It seems impossible that they should have invented it; but the fact remains that they make "sumpits," and make the bores of them mathematically true with the simple tools mentioned above, while it would need a skilled European workman, aided by every improvement of modern lathe machinery, to make so good a weapon.



MERIDIAN INSTRUMENT, BESANÇON.

REPSOLD'S MEASURING APPARATUS FOR PHOTOGRAPHIC PLATES.

Armor plate for battleships may cost as much as $400 per ton, according to the unanimous recommendation of the Senate Naval Committee.

GREEN FRUIT WORMS.*

Xylina antennata Walk.
Xylina laticinerea Grt.
Xylina grotei Riley.

Order LEPIDOPTERA ; family NOCTUIDAE.

IN New York State, the year 1896 was marked by the appearance in destructive numbers of several insects which have not been noticeably injurious here during the past decade or more. The army worm, which in July ravaged field crops in nearly every county in the State, is a familiar example; and the insects discussed in this bulletin also afford another illustration of this fact.

WHAT THEY ARE.

These green fruit worms are large, light yellowish or apple green caterpillars, with a narrow cream colored stripe down the middle of the back, a wide cream colored stripe along each side, and many similarly colored mottlings or spots which sometimes form quite distinct stripes along the body above the broad lateral stripes. When fully grown they range from an inch to an inch and a half in length. One of them is shown at work at a, plate 2. Figs. f and g, plate 1; c and d, plate 3; and b, plate 2, are from photographs of the worms taken twice their natural size. Like many other caterpillars, these green fruit worms are the offspring or younger stage of insects known as moths or millers. These adult forms are represented natural size at b, plate 1; at a, plate 3; and at f, plate 2; and also twice natural size in the same plates.

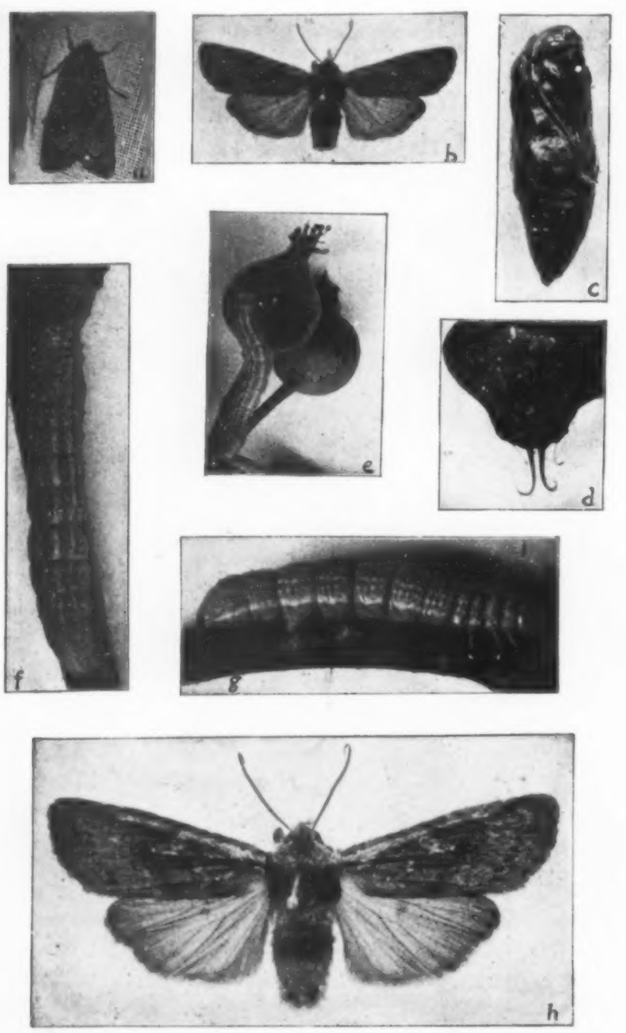


PLATE I.—XYLINA ANTENNATA, WALKER.

a, the moth at rest, natural size ; b, the moth, natural size ; c, the pupa, enlarged ; d, caudal segment of the pupa, much enlarged ; e, the caterpillar at work, natural size ; f and g, the caterpillar, dorsal and lateral views, twice natural size ; h, the moth, twice natural size.

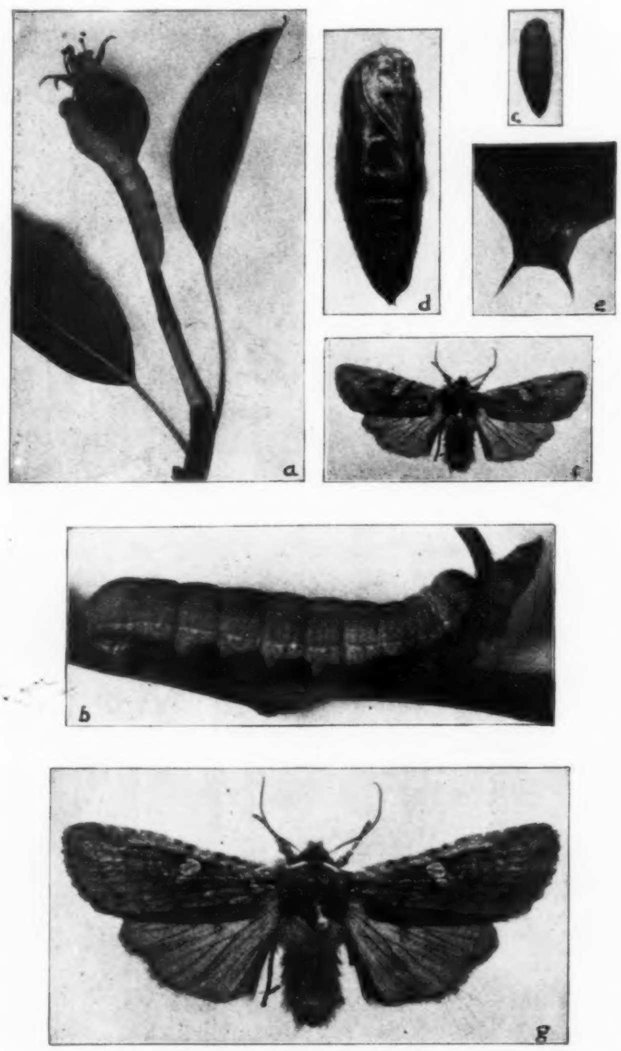


PLATE II.—XYLINA LATICINEREA, GROTE.

a, the caterpillar at work, natural size ; b, the caterpillar, twice natural size ; c, the pupa, natural size ; d, the pupa, enlarged ; e, caudal segment of pupa, much enlarged ; f, the moth, natural size ; g, the moth, twice natural size.

HABITS AND FOOD OF THE CATERPILLARS AND MOTHS.

For several years before the fruit-eating habit of these green fruit worms was discovered, they were known to feed upon the leaves of the apple and several forest trees; the leaves of poplar, hickory, wild cherry, box elder, and the buds of roses are recorded among their food plants. During the summer of 1870, however, the insects attracted unusual attention in Missouri and Illinois by being frequently found eating or boring into apples, peaches and the spongy oak apple (a large applelike swelling or gall often produced on oak leaves by a minute gall fly). Last year pears, peaches, plums, currants, and quinces were eaten in New York State, but the caterpillers confined themselves mostly to an apple diet. We have not observed the worms boring into the fruit. They simply begin eating on one side and often continue feeding until nearly half of the fruit is eaten, leaving a large cavity on that side (see Fig. a, plate 2). They work during May and the first half of June, and are not to be found on the trees again during the year.

The insects go from fruit to fruit, one caterpillar thus ruining several fruits; an instance is recorded of one worm destroying six of the eight quinces on a tree. The caterpillars feed during the day, and probably also at night. When young they doubtless feed upon the foliage or buds, for, when the fruit is large enough for them to eat, the worms are found to be half grown or more. One of our correspondents writes :

"We grafted some young Dutchess pear trees this spring, and have had to watch them continually to keep these worms from destroying the buds."

We have found some of the caterpillars apparently resting during the day on a silken web spun on one side of a partly rolled leaf; some of our correspondents have also observed this. We suspect that this is not a normal habit of the insects, for the only occasion we saw it resorted to in our cages was in the case of the caterpillar shown in Fig. d, plate 4; it was suffering from a serious internal trouble in the form of a parasitic grub which finally came out and fastened the worm to the leaf with its silken cocoon (see the figure).

Dr. Riley has recorded that the caterpillars can pinch with their little jaws quite sharply, so as to draw a little blood from a tender part. The worms are easily disturbed at their work of feeding on the fruits, for if the tree or limb be suddenly jarred, they at once drop to the ground, not spinning down by a silken thread as do the canker worms.

The parents of these green fruit worms—the moths—are night fliers, remaining concealed on the bark of the trees or in other secluded places during the day. Most of them appear during September and October, and, hibernating in sheltered places, appear again in March, April and May; some evidently remain in the ground as pupæ over winter, the moths not appearing until spring. They are readily attracted to lights or sweetened baits at night, and are "often found in maple groves while sugaring is going on. Sometimes sap pails are found in the morning with the surface of the liquid completely covered with the moths."

THEIR HISTORY AND DISTRIBUTION.

These green fruit worms first attracted serious attention by boring into apples and pears in 1870, in Missouri and Illinois. Dr. Riley also states that he had seen them for several years previously on the foliage of different trees. A newspaper slip, written in 1872, states that the insects were very common and destructive in the South, where the worms made their appearance during April and May, in the latitude of Mobile and New Orleans. In 1877 the caterpillars appeared in large numbers in the orchards in the vicinity of Lockport, N. Y. Prof. Comstock investigated this outbreak and found that much damage had been done in many apple and pear orchards. In the case of one young pear orchard, he counted the whole number of pears on several trees and found that 45 per cent. of them had been injured by the caterpillars. It was noted that this orchard was adjoining a forest from which the insects may have spread. It is a curious fact that although these green fruit worms were so numerous in 1877, they seem not to have attracted attention again anywhere in New York State until 1896, nineteen years later. In 1888, quite a number of apples were found apparently injured by these caterpillars in Maine.

The adult insects—the moths—are not uncommon in Canada and the northern and eastern portions of the United States; and the insects have been recorded as injurious in the South and as far west as Nevada. Collectors report the moths as common in, and we have this year received the caterpillars from, several widely separated localities in New York State. Thus, these fruit-eating caterpillars are very generally distributed throughout Canada and the United States.

THEIR LIFE HISTORY.

The green fruit worms do most of their damage to the young fruits in May, but some of them continue working until nearly the middle of June. During the first week in June most of the caterpillars get their full growth and then burrow into the soil beneath the trees to a depth of from an inch to three inches. Here they roll and twist their bodies about until a smooth earthen cell is formed. Most of them then spin about themselves a very thin silken cocoon; some spin no cocoon. Within the cocoon or the earthen cell, the caterpillar soon undergoes a wonderful transformation which results in what is known as the pupa of the insect. One of these dark brown, lifeless looking pupæ is shown, natural size, at c, plate 2, and enlarged on the same plate. Most of these insects spend about three months of their life in the ground during the summer in this pupal stage. Some evidently hibernate as pupæ, and thus pass nine months or more of their life in this stage. Usually about September 15 the moths break their pupal shrouds and work their way to the surface of the soil. Most of them emerge in the fall before October 15, and pass the winter as moths in sheltered nooks; some evidently do not emerge until spring. Warm spells in winter sometimes arouse a few of them from their hibernation.

During the first warm days of early spring, all the moths appear, and doubtless the mothers soon begin laying eggs. No observations have been made on the eggs or young caterpillars in the North, but in a news-

* By M. V. Slingerland. From Bulletin 123, Cornell University Agricultural Experiment Station, Ithaca, N. Y.

paper article published in the South in 1872, it is stated that the eggs are deposited in the spring on the undersides of the leaves. They hatch in a few days, and the young worms begin at once to eat the foliage, or the fruit, or both.

There is thus but one brood of these green fruit worms in a year. They work mostly in May, pupate in the soil in June, live as pupæ during the summer and sometimes all winter, and most of the moths emerge in the fall and hibernate, laying their eggs in the spring.

THE DIFFERENT SPECIES DISCUSSED.

In all previous discussions of an economic nature regarding these green fruit worms they have been considered as comprising but a single species of insect, namely, the ash-gray pinion (Xylina antennata). However, when the specimens of the caterpillars began to arrive at the insectary last spring, it was soon evident that there were at least two quite different kinds. We grew the supposed two species separately in our cages. When the moths appeared in September, they were sent to an expert, Professor J. B. Smith, for determination. He returned them labeled as three distinct species! We had thus bred two species of moths in the cage where we thought we had only one kind of green fruit worm. As the moths of all three species showed remarkable resemblances to each other* (compare Figs. b and h, plate 1, Figs. a and b, plate 3, and Figs. f and g, plate 2), we at once began a search for characters which might separate the insects in their caterpillar or pupal stages. It had been an easy matter from the first to separate the caterpillars into two distinct kinds, as represented in Figs. e, plate 1, and a, plate 2, or g, plate 1, and b, plate 2. It was also found that the pupæ developed from these two kinds of caterpillars were quite different; this difference is well shown in Figs. d, plate 1, and e, plate 2. Very fortunately, through the kindness of Mr. L. O. Howard, United States Entomologist, we were able to examine the single specimen preserved of the caterpillars which Dr. Riley had under observation when he wrote of the insect in 1870. This specimen (figured at c and d, plate 3, twice natural size) revealed some characters which we had overlooked and enabled us to separate the caterpillars we had had in one cage into two species. We were also able to connect each species of caterpillar with the moth of the same species. In the discussion of the three species which follows, the differences mentioned above and several others are more fully brought out.

1. XYLINA ANTENNATA WALK.

About three-fourths of all the green fruit worms sent to the insectary were of this species; from some localities, however, nearly as many of the next species discussed were received.

As early as 1858 a moth of this species (habitat unknown) found its way into the British Museum, and was there first described and named. When Dr. Riley discussed these green fruit worms in 1871 he also described the moths and named them Xylina cinerea. In 1879, specimens of X. cinerea were taken to England by Dr. Fernald and there compared with Walker's X. antennata, and the identity of the insects thus established. In 1882 Dr. Riley stated (Papilio, II, 101) that his description of the moths of these insects included all three of the species to be discussed here; but he considered two of the forms as only varieties, and not distinct species. Mr. A. G. Butler of the British Museum has recently also expressed his opinion (the Entomologist for 1891, p. 242) that all three forms were only variations of a single species, X. antennata. Our authorities on this group of moths, Prof. Smith and Mr. Grote, however, have considered them as three distinct species; and our study of the earlier stages of the insects confirms this conclusion.

As all three species apparently occur in the same localities, and as the moths are so remarkably similar in size, color, and markings, it is not surprising that they should be classed as varieties of one species. We have never before seen three species of moths which showed such remarkable resemblances to each other and yet were quite different in their caterpillar and pupal stages.

At a, on plate 1, is shown a moth of X. antennata, natural size; the figure is reproduced from a photograph taken from life while the moth was at rest in the top of one of our cages. At b, plate 1, the moth is shown with wings expanded, natural size, and at h is shown same moth, twice natural size. These figures will show the size and markings of the moth, and also represent nearly its natural color. It usually differs from the moth of X. laticinerea in the ground color of its wings being of a more brownish cast; and from the moth of X. grotei in that its markings are not so bright and distinct. There may be slight antennal differences in the males of the three species, and there are certainly quite marked differences in the genitalia of X. antennata and X. grotei, as is shown, enlarged, at g and f, plate 3.

As was stated in the general discussion of the life history of these green fruit worms, doubtless egg laying takes place early in the spring, and the young caterpillars feed upon the buds and leaves until May, when the fruit is large enough for them to eat. The further life history of this species follows closely the general account just mentioned.

The caterpillar of this species is figured in our engraving twice natural size, both lateral and dorsal views at f and g, plate 1. It is of a light apple green color, sometimes yellowish, with the head of nearly the same color, and the venter darker. As the figures show, the hair-bearing spots are white and very distinct. A narrow mesal cream-colored stripe, slightly wider near the middle of the body, extends along the dorsum; there is a slightly narrower, but distinct subdorsal stripe of the same color that is somewhat broken toward the extremities; there is also a wide, stigmatal, cream-colored stripe, mostly below the spiracles, with its lower or ventral edge sharply defined, but with its upper or dorsal edge much indented with the body color and irregularly extending to a much broken, narrow, lateral stripe of cream colored spots a little above the spiracles. Most of these characteristic markings are well shown in the figures at f and g, plate 1. The caterpillars spin a very thin cocoon of silk about themselves in their earthen cell before they change to pupæ.

The brown pupa, shown enlarged at e, plate 1, resembles in size and general appearance that of X. laticinerea shown at e and d, plate 2. But a close examination of the caudal end of the pupæ of these two species reveals striking differences. These are well shown in the enlarged figures of this portion of the pupæ at d, plate 1, and e, plate 2.

2. XYLINA LATICINEREA GRT.

This green fruit worm was represented among the specimens received from each locality, and, in one or two instances, it seemed to be equally as numerous as the preceding species.

The moth of X. laticinerea was first described and named in 1874 from a Massachusetts specimen. The insect is illustrated on plate 2, Figs. f and g representing the moth, natural size and twice natural size, respectively. It seems to differ from the moth of X. antennata in the ground color of the wings being of a more decidedly ash-gray color and the markings are possibly a little more distinct; a comparison of the figures of the two species, shown on plates 1 and 2, will show that they are very similar. There may be antennal and genitalic differences in the males also; having bred no males of laticinerea, we cannot verify this.

Nothing has been recorded respecting the life history or earlier stages of this species; the caterpillar described by Mr. Edwards (Papilio, III, 135) as belonging to this insect, was certainly another species, probably X. grotei, as we shall see later. Our observations show that the caterpillars appear in May with, and have the same habits as, those of X. antennata. Pupation takes place in earthen cells in the soil about the same time in June. But the caterpillars of X. laticinerea spin no trace of a cocoon. The insect remains in the pupa state until fall, when some of them give forth the moth, but in our cages most of the pupæ are now hibernating; one moth emerged September 26.

A comparison of the figures of the caterpillar of this species at a and b, plate 2, with those of the other two species represented on plates 1 and 3 will at once show that it is quite different from either of the others. It is of a light apple green color, sometimes with a slight

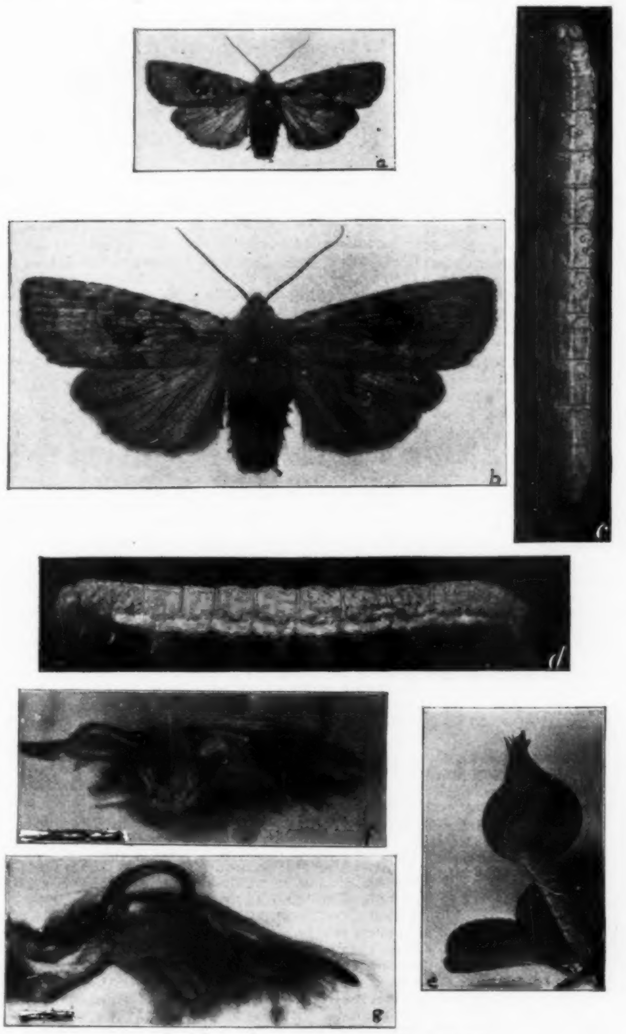


PLATE III.—XYLINA GROTEI, RILEY.

a, the moth, natural size; b, the moth, twice natural size; c and d, the caterpillar, dorsal and lateral views, twice natural size; e, the caterpillar at work, natural size; f, genitalia (right half) of the male of Xylina grotei, much enlarged; g, genitalia (right half) of the male of Xylina antennata, much enlarged.

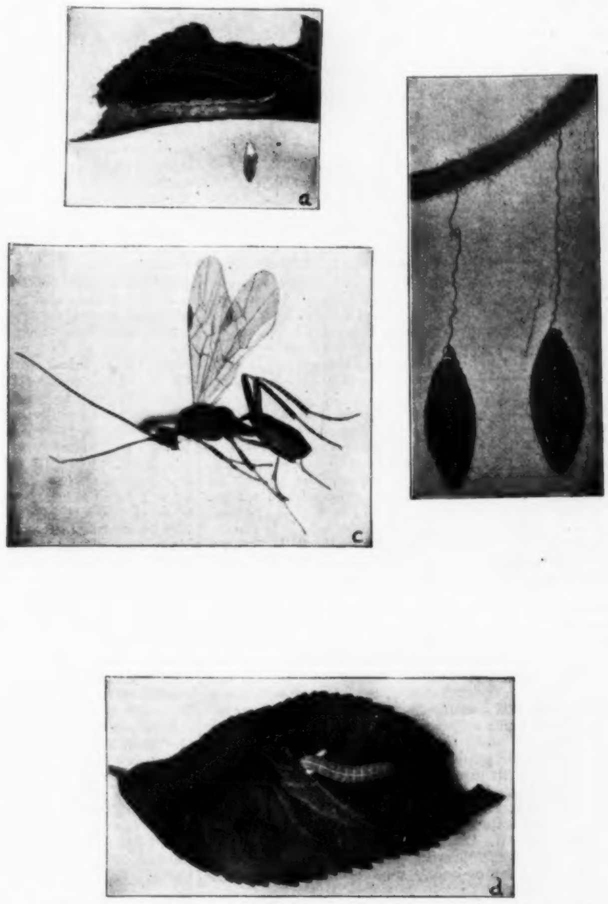


PLATE IV.—SOME OF THE ENEMIES OF GREEN FRUIT WORMS.

a, caterpillar of Xylina laticinerea from which the parasitic grub of Meteorus hyphantriae has just emerged and is spinning its cocoon, natural size; b, two of the curious suspended cocoons of Meteorus hyphantriae, enlarged; c, the adult parasite (Meteorus hyphantriae) much enlarged; d, a caterpillar of Xylina laticinerea killed by the parasitic grub of Mesochorus agilis which has spun its cocoon beneath the caterpillar, fastening the latter to the leaf, natural size.

* Professor Smith writes: "As I have them divided in my collection, you can tell the difference between them; but if you undertake to locate it, you will become lost in a short time."

bluish cast; the head is sometimes a little lighter, and the venter is but slightly darker. The whole body is very finely mottled with minute cream colored spots, and the hair-bearing spots are small and not very distinct. There is a narrow cream colored mesal stripe on the dorsum, wider near the middle of the body; the narrow light lemon yellow stigmatal stripe, widest toward the extremities, runs just above the spiracles, except in the case of the spiracle nearest each extremity, where it runs below; there is also a very narrow, much broken, sometimes quite indistinct, cream colored stripe midway between the mesal and stigmatal stripes. On some specimens the yellow stigmatal stripe was bordered above with a blackish shade, as shown on the parasitized caterpillar at a, plate 4. A comparison of this description of the caterpillar with that of Mr. Edwards, referred to above, will show that they cannot apply to the same insect; for the lemon-yellow stripe is narrow and above the spiracles, and not broad and below, as in Mr. Edwards' description.

The pupa of this species is not formed within a cocoon, and also differs from that of X. antennata very strikingly in the structure of its caudal segment, as is well shown by a comparison of the enlarged figures of this part at d, plate 1, and e, plate 2. Otherwise the pupæ are quite similar, as the enlarged figures at c, plate 1, and d, plate 2, show.

Although the moths of X. antennata and X. laticinerea are distinguished from each other with considerable difficulty, the above descriptions and the accompanying figures show that the caterpillars and pupæ of the two species are quite distinct and can be easily separated. Thus both insects are distinct and valid species.

3. XYLINA GROTEI RILEY.

Only a small percentage of the green fruit worms sent us proved to be of this species.

The moth was first described as X. cinerosa in 1879, from New York State specimens. In 1882 Dr. Riley pointed out that this name could not be used, as another insect belonging to the same genus had received the same name years before. He suggested the name X. grotei instead, but thought the insect was only a variety of X. antennata. Nothing has since been recorded about the species.

A comparison of the figures of the moth at a and b, plate 3, with the figures of the moths of the other two species on plates 1 and 2 will show how remarkably similar the insects are in the adult state. The moths of X. grotei have a much brighter appearance and their markings are more sharply defined than in either of the other two species. The ground color of their wings is much like that of X. antennata, but there is a decided difference in the male genitalia of these two species, as is shown in the enlarged figures at f and g, plate 3. Our specimens of the moths of X. grotei emerged from the 18th to the 26th of September. We have found no recorded captures of this species. Doubtless its life history is very similar to that of X. antennata.

The caterpillars of X. grotei so closely resemble those of X. antennata that we did not notice their characteristic differences until the moths which appeared in one of our cages were determined as two distinct species; and until we had seen the only caterpillar preserved by Dr. Riley when he studied these green fruit worms in 1870. The caterpillar at e, plate 3, is of this species; figures c and d, plate 3, are reproductions of photographs taken twice natural size from Dr. Riley's preserved (blown) specimen. Compare these figures with those of the caterpillars of X. antennata at e, f and g, plate 1. The difference between the broad stigmatal stripes is readily seen; in X. grotei, both edges of the stripe are quite sharply defined, while in X. antennata the upper edge is much broken or indented with the body color. Another difference readily seen on the specimens, but not so evident in the figures, is that the subdorsal stripes in X. grotei are not so continuous as in X. antennata, but are made up of three or four irregular spots on each segment. Otherwise, as regards general color, size, etc., the caterpillars of these two species are practically alike. Dr. Riley's description of his green fruit worm agrees with his preserved specimen of X. grotei, and he states that the moth of this species (a variety, he then considered it) "heads his series." Mr. Edwards described a caterpillar of what he supposed was X. laticinerea, but his description applies to the caterpillars of X. grotei, and not to those of either of the other two species under discussion.

The indications are that the caterpillars of X. grotei spin slight cocoons within which they change to pupæ, as in the case of X. antennata. But we cannot say whether there are any differences in the pupæ of these two species or not.

NATURAL ENEMIES.

Fortunately for the fruit grower, these green fruit worms have several deadly enemies. One correspondent reported that red winged black birds had been seen either catching and eating the caterpillars or carrying them away to feed their young. Doubtless other birds which frequent orchards also include the worms in their menu.

The indications are, however, that the caterpillars suffered much more from the attacks of at least two minute foes among their own kind. From the material sent to the insectary, we bred two minute hymenopterous parasites. Apparently the most numerous and efficient one of these little enemies is shown much enlarged at c, plate 4; they are only about ⅛ of an inch in length. It was named Meteorus hyphantriæ by Dr. Riley in 1886. That year it did valiant work in checking the fall web worms (Hyphantria cunea). Its method of working is to deftly insert an egg into the body of an unwary and defenseless caterpillar. A grub hatches from this egg and proceeds to live on the internal fats and juices of its host—the caterpillar. The host leads a lingering existence, and finally a short time before death ensues, the parasitic grub bores its way out through the skin of its host and proceeds to spin the curious brown cocoon, shown natural size at a, and much enlarged at b, plate 4. Just how the grub manages to make these suspended cocoons is not known. Apparently it first spins out the large suspending silken thread and then at the end of this, holding on in some manner (perhaps by its jaws), it proceeds to spin about itself a coarse, loose cradle of the same kind of silk. When secure inside this cradle it lets go its hold from the suspensory thread and spins its soft, dense, fine threaded cocoon. These cocoons are attached to any part of the tree and the threads that suspend them vary in length from one-half inch to four inches. From ten days to two weeks (in June) after the grub spins its cocoon the transformation through the pupal to the adult stage takes place. The little four winged foe then emerges through a round hole made in the end of the cocoon, by deftly gnawing around the lower end and thus detaching a neatly fitting cap.

The other little enemy of these green fruit worms is about the same size as and looks something like the one just described. It also works inside the caterpillars in the same manner, gradually sapping out their life. But instead of undergoing its further transformations in a suspended cocoon, it bores its way out of the caterpillar and, crawling beneath its host, it proceeds to fasten the latter down to a leaf with its cocoon. This state of affairs is well shown at d, in plate 4. The two-thirds grown caterpillar is pinioned to the leaf by the cocoon of the grub which caused it to die a lingering death. This little parasitic foe is known to science as Mesochorus agilis.

Doubtless the efficient work of these little parasitic insects and the birds has been one of the main reasons why these green fruit worms have troubled New York fruit growers only at long intervals.

HOW TO COMBAT THESE FRUIT EATING CATERPILLARS.

It is to be hoped that these caterpillars will not often visit our orchards in destructive numbers, for the past season's experience has shown that it is a difficult matter to check their ravages. It would seem at first thought that the pests might be readily killed with a Paris green spray. But several of our correspondents, who have a reputation for thoroughness in spraying and who successfully check fungi and other insects, reported that all of their efforts in this line did not noticeably diminish the crop of these caterpillars. Some sprayed with the poison three or four times during the time the worms were at work. Mr. Albert Wood, Carlton, N. Y., collected sixty live worms and placed twenty on each of three large branches loaded with young apples; the branches were cut off and nailed up somewhere. One branch was sprayed with kerosene emulsion, one with arsenate of lead, and the third with hellebore. Two days after, the worms were all lively and well, and had kept on eating apples. The orchard from which these worms were taken had received three thorough applications of Bordeaux mixture and Paris green.

It is possible that one or two thorough applications of Paris green made before the blossoms open, when the caterpillars are small and feeding on the buds and leaves, might kill many of them. However, the consensus of opinion among our correspondents seems to be that they cannot be effectually reached with a spray at any time. It is probably true that it is practically impossible to sufficiently coat the outside of a young apple with a poison spray so that one of the caterpillars would get enough to kill it when it eats into the fruit. For this reason we concur in the belief that the worms cannot be effectually checked with a spray of any kind after the fruit gets large enough for them to feed upon it. But the young worms must feed upon the buds and leaves for a time before the fruit gets large enough, and it seems plausible that a Paris green spray, thoroughly applied at least once before the trees blossom, must result in the death of many of the worms. We would like to see this tried, but there is one difficulty which will always arise; that is, one can rarely, if ever, tell whether the insects are present in his orchard in destructive numbers until they begin to eat the fruit. It is always a good practice, however, to spray orchard fruits at least once (where bud moths or case bearers are thick, twice) before the blossoms open with the combined Bordeaux and Paris green.

One correspondent writes that the caterpillars were the most numerous in a cultivated orchard. This does not agree with the observations of Professor Comstock made during the outbreak in 1877; he states that the fruit was injured most in those orchards which were not cultivated. This fact led him to recommend that many of the insects could be destroyed by the cultivation of the orchards during July and August, while the worms are in the ground undergoing their transformations. We believe that thorough cultivation during the summer will tend to greatly lessen the crop of green fruit worms for the following year.

The fact reported by several correspondents, that the caterpillars will at once drop to the ground (not spin down as do canker worms) when the branch upon which they are at work is unnaturally jarred, affords a vulnerable point of attack against them. Why not jar them off into sheets and then kill them? We saw this successfully accomplished last spring in an orchard near Geneva, N. Y. "Curculio catchers" were in daily use to catch this most serious pest of stone fruits, and hundreds of the green fruit worms were being caught at the same time, thus "killing two birds with one stone." On young trees this is the most efficient and practicable method of fighting these caterpillars we can suggest. Three or four good thorough jarrings ought to effectually check their ravages for the season. Of course, on old, large trees it would be a big undertaking to jar them, and when there was such a setting of fruit as we had last spring it might not pay to do it. But with a small setting of fruit, it might mean the difference between a good crop and no crop at all, in which case it would certainly pay.

In brief then, our recommendations for fighting these fruit-eating caterpillars are to always spray the trees at least once with Paris green in the Bordeaux mixture before the blossoms open, to kill some of the worms while they are young. Later sprayings, after the fruit is large enough for them to eat, will avail but little. After the fruit sets, the only successful and practicable way to fight them seems to be by jarring them off into sheets or "curculio catchers" and killing them. Follow this with thorough cultivation of the soil during the summer, and thus kill many of the insects while they are undergoing their transformations in the soil. They are difficult pests to fight, and it is to be hoped that at least another nineteen years may pass before our fruit growers receive a third visitation from destructive numbers of them.

SELECTED FORMULÆ.

Printing on Marble.—Mr. Villon publishes the following process for printing on marble: Coat an unpolished plate of marble with the following solution:

Benzine	500 parts.
Spirits of turpentine	500 "
Asphaltum	50 "
Pure wax	5 "

When dry, expose under a negative, which will take in sunshine about twenty minutes. Develop with spirits of turpentine or benzine, and wash in plenty of water. Now cover the plate where it is intended to be left white with an alcoholic solution of shellac, and immerse the same in any dye which is soluble in water. After a while, when enough of the coloring matter has entered the pores of the stone, it is taken out and polished. The effect is said to be very pretty.—Photographisches Archiv.

To Prevent Scale in Boilers.—Kerosene has been recommended to prevent scale in steam boilers, both because of its cheapness and since it leaves no residue and has no injurious effect on the iron. An injector is used so constructed that the amount of kerosene which is fed into the boiler drop by drop can be very closely regulated.—Jour. Soc. Chem Ind., xvi, 226, after Eng. and Mining Jour., lxiii, 45.

Preventive and Healing Agent for Insect Bites.—

Acetic ether	5 parts.
Eucalyptol } of each	10 "
Cologne spirits }	
Tr. Persian insect flowers	50 "

This is to be mixed with 3 parts of water and used to bathe the hands and face.—Pharmaceutical Era.

To Give a Copper Color to Solder.—We often have inquiries as to the best method of giving a copper color to solder that accidentally or unavoidably appears on the outer surface of a piece of architectural sheet copper work. During a recent visit to the shop of Rasner & Dinger, Pittsburg, Pa., a very simple method of accomplishing this work was witnessed. In a cup one-quarter full of water was placed two or three spoonfuls of powdered blue vitriol (sulphate of copper), and when dissolved the solution was applied to the solder with a brush. As soon as the liquid touched the bright metal a film of copper spread over it, and by freely applying the solution a fairly substantial coating of copper was produced. If on trial of this method a coating is not obtained, it is likely that the solution is not strong enough, and the remedy is simply to add a little more blue vitriol.—The Metal Worker.

Removal of Blood Stains.—The best way to remove blood stains, says the Centralbl. f. Gyn., is to soak the towels, etc., in warm water, to which a teaspoonful of tartaric acid has been added. No soap is needed.—Med. Times.

To Measure Hot Liquids.—In making up photographic formulæ it is often necessary or convenient to measure hot water, or other fluid, and if this is done in an ordinary thick glass measure there is considerable risk of cracking or fracture. To obviate this get a thin glass beaker (preferably one with a spout), such as is used in chemical analysis. All sizes may be had, and the price is about one shilling for a beaker holding 20 ounces. They can also be purchased in "nests" of three or four. Take a strip of gummed paper and fix it down one side of the beaker. Then graduate by pouring in measured quantities of water, and marking the paper in pencil at each level. Next size and varnish the strip of paper, letting the varnish come well over the edge.—Photographic News.

The Removal of Embedded Powder Grains.—Dr. Edward Jackson, of Philadelphia, contributes a very useful paper on this subject in the Albany Medical Annals, May, 1897. On the face the operation is of most importance in consequence of the disfigurement. If any grains are situated superficially a good deal of spontaneous improvement will occur, as they will be thrown off with the epithelium. To favor this poulticing or blistering may be tried. But the deeper particles will not be affected. At first they are massed in small areas which give the appearance of black grains capable of removal singly. But even at this stage they are so incorporated with the tissues that this is impossible. A recognition of this fact will save the patient unnecessary pain and the surgeon disappointment. The problem is really the removal of the tissue in which they are diffused with the least possible destruction. After failure of many methods, Dr. Jackson used a fine pointed galvano-cautery, with which he destroys each spot. The earlier it is applied, the less is the tissue which has to be destroyed, for as time goes on the stain becomes diffused. In old cases where the whole skin of the part is involved the method cannot be employed. As repeated applications are often necessary (in one case he made 300 at a single sitting) an anæsthetic is required. Ether is inadmissible, therefore he uses chloroform. Where the number of grains is small, local anæsthesia in the form of Schleich's infiltration method may be employed. The tip of the cautery at a white heat is quickly introduced to the necessary depth and quickly withdrawn. In severe cases it is impossible to judge correctly the depth, so that repetition may be necessary. For grains embedded in the cornea the operation is precisely that of cauterizing for ulcer.—London Lancet.

Washing Bromides.—The best way of washing bromide prints, unless you have a proper washer, is to throw them face downward in a basin of water. They will then float on the surface of the water, and the hypo, when dissolved, will sink to the bottom of the basin, the water of which must be changed every quarter of an hour or so. At the end of two hours the prints will be found to be quite free of hypo, and can be allowed to dry, to do which they ought to be hung up by clips in a warm room.—Photographic News.

Blocking Out Skies in Negatives.—The following is a very simple way for blocking out skies, and, if properly done, acts very well. Place the negative, film side uppermost, over a lighted candle so that the soot falls on the glass side of the negative, wipe the soot off where not required, and it may be printed from with a piece of tissue paper over the top of the frame.

ENGINEERING NOTES.

The Société John Cockerill at Seraing, Belgium, about a year ago put up a gas engine which has been run with gas taken from one of the blast furnaces, which had previously been wasted, says the Engineering and Mining Journal. The experiment has proved so satisfactory that the company has ordered two engines of 150 horse power each to be run in the same way.

The project for a tunnel under the Irish Channel has been several times discussed, and has now again been brought before the public. The plan is to build a tunnel under the Irish Channel from Portpatrick to Donaghadee, a distance of 21 miles. Several engineers have made examinations and estimates which put the cost between \$30,000,000 and \$40,000,000. It is believed that a very large business could be secured for the tunnel.

An electric turntable recently placed in operation at the West Milwaukee shops of the Chicago, Milwaukee & St. Paul Railway has been handling its work admirably, says the Railway Master Mechanic. The turntable and pit are of the ordinary construction. The table is operated by a little one-wheel electric car which rides on the pit track and pushes or pulls the table around. The current is carried to the dynamo by an overhead wire leading to an arch set on the center of the table. The table is turned, light, in thirty seconds, and with a 100 ton load in forty-five seconds.

Methods of testing iron and steel and other structural material have long received close study abroad, and with a view to standardizing these methods an International Association for Testing Technical Materials was decided upon at an international congress held at Zurich in 1895. This association has since been organized, and it will establish an International Research Library for iron and steel at Zurich, Switzerland, which city has donated a suitable building. Baron Juptner, a man of fame in connection with work of this nature, has been selected as director of the laboratory, says the Railway Master Mechanic. The laboratory is to be sustained by contributions from the various countries in proportion to their production.

In the way of rapid railway construction the contract just taken for building an electric road from Marion to Anderson, Indiana, is remarkable, says the Railway Age. It is agreed to grade, bridge and iron the 39 miles of road, construct two large power houses, with their engines, boilers and motors, and place the poles, overhead construction, feeder wires and other necessary appliances within 100 days. There are 22 bridges to be erected, over 200,000 yards of grading to be done, and much brick paving in towns to be torn up and replaced. The road is to be part of an electric line 74 miles long passing through the Indiana gas belt, and it is to be a direct competitor with several steam roads in carrying express matter as well as passengers. The quickness and cheapness with which a competing line can now be dropped down beside long established roads constitute a menace to railway interests which is just beginning to be appreciated.

The Boynton Bicycle Railway is again before the public in Massachusetts. A subcommittee of the legislature reported on May 13 a bill incorporating the Boston, Quincy & Fall River Bicycle Railway Company, to build a railway from Quincy to Fall River, on locations to be determined by the local authorities of the towns through which the railway will pass. The incorporators include Gen. O. O. Howard, Albert H. Overman, E. Moody Boynton and Edward O. Perkins. The company is empowered to carry passengers, but no freight, must operate its road by electricity, and its structure must be approved by the State railroad commissioners. A bicycle railway is also projected in Amesbury, Mass., to run from the Boston & Maine railway station, in that town, to the railway station in the neighboring town of Exeter, about 8½ miles. By the terms of the charter, surveys for the road must begin not later than June 11, 1897.

Among the various departments that go to make up the striking assemblage of architecture, art, science, mechanical devices, and industrial products of the Tennessee Exposition at Nashville, the power plant of the Exposition is in itself an example of modern progress and up to date efficiency. It occupies two separate buildings, consisting of a boiler and engine house. There are four 500 horse power and two 250 horse power Climax boilers, constructed to carry 120 pound pressure. The engines in the power house proper consist of four Westinghouse compound engines. These are non-condensing, 18 and 36 × 16, furnishing about 400 horse power each for electric lighting and electric power. Steam is furnished to the machinery building, where it operates one Hamilton-Corliss engine, 24 × 48, of 500 horse power, one Lane & Bodley Corliss engine, 22 × 48, of 400 horse power, one Phenix engine, of 150 horse power, connected to a 100 kilowatt Western Electric generator, and a 100 horse power Weston engine, connected to an 80 kilowatt Triumph generator. Feed and fire pumps are of the Laidlaw-Dunn-Gordon and Worthington types.

A series of experiments on the resistance of cements to sea water was begun in 1856 at the harbor of La Rochelle, and is described in the Thonindustrie Zeitung by E. Candlot. The experiments consisted, says Science, in placing cubes of cement of different compositions, 60 centimeters long, where they would be covered by the sea at high tide and exposed to the air at low water. Blocks of cement without sand disintegrated more rapidly than those containing sand, and the best mixture was one volume of cement with from one to two volumes of sand. Such blocks lasted from twenty to thirty-eight years. This mixture corresponds to the least porous material, that is, the cement suffices to completely fill the interstices between the grains of sand. An excess of lime or magnesia in the cement is detrimental. This occurs when the quantity of silica and alumina is insufficient to saturate these bases. The best cement is that which requires least water for mixing, relative to the amount which it can hold chemically combined when "set." Portland cement was found to require very little excess of water, and hence gave the densest and least porous results and the maximum durability.

ELECTRICAL NOTES.

The poles of the telegraph lines in Europe are said to have cost \$50,000,000. The basis of this curious estimate is not given.

According to Gluckauf, the largest pumps driven electrically that have yet been constructed in Europe are being erected at the Kubeck shaft, Anina, Hungary. The plant consists of two three-ram pumps, each of which is designed to raise 176 gallons of water per minute, to a height of 787 ft., driven by two electromotors, each of 60 horse power, making 550 revolutions per minute.

For such as are interested in telephonic appliances, it might be mentioned that Dr. Von Stephan gives the following requirements for an automatic call register: It must work accurately, the cost of construction must not be too great; the instrument should not interfere with the action of the telephone, or demand frequent reparation. It should, moreover, occupy but a small space.—Uhland's Wochenschrift.

At the mines of the Upper Hungarian Mining and Iron Works Company, Szomolnokhuta, an electrically driven duplex pump is being erected for raising 154 gallons per minute to a height of 328 ft. Special interest is attached to this plant because of the metallic composition of which the rams and suction pipes are cast, and the fact that the cast iron delivery pipes are lined with asphalt, on account of the very acid water.

The cables for the underground telegraph connection between Paris and Marseilles are placed in iron pipes 4 ft. under the surface of the ground and connected by means of lead and rubber rings. At distances of 3,000 ft. the cable passes through an iron chamber large enough to hold a man, and at every 400 ft. there are iron boxes which also facilitate the inspection and repair of the cable. The total expenditure is very considerable, amounting to some £1,400,000.

Senator Pettigrew, of South Dakota, has introduced a bill authorizing the postmaster general to acquire for the use of the United States the right to use any new method of rapid telegraphy which has been developed by Prof. Crehore and Lieut. Squier or others. The postmaster general is also authorized to construct a telegraph line of the best copper wire or other material adapted for the purpose, for the purpose of experimenting and perfecting the use of rapid telegraphing. For the purpose of carrying out the provisions of this act, he asked for the appropriation of \$1,000,000. It is very doubtful if such a bill would pass, as the government has always been very loath to spend money on experiments.

A report of the State Board of Assessors giving figures about the electric and street railroads in New Jersey for the year 1896 shows total receipts \$5,770,171, against \$5,056,598 in 1895, an increase of \$713,573. The expenditures were \$3,546,168, against \$3,431,931 in 1895, an increase of \$114,236, and dividends paid \$124,220, against \$117,320 in 1895, an increase of \$6,900. The number of miles of track in the State is 613; capital stock paid in, \$38,235,150; funded debt, \$36,420,493, and other debts, \$4,279,396; total of capital and funded and unfunded debt, \$78,935,039. The total cost of railroads, says the Electrical Engineer, including the equipment and appurtenances, is put at \$80,011,559, an average of \$130,000 per mile of track.

An illustrated description of the switches used in Portsmouth, by means of which incandescent lamps are substituted for arc lights for street lighting after the latter have been extinguished at midnight, was recently described in the English Electrical Review. This automatic switch is in use on 240 lamp posts. When the arc lamps are turned off, the incandescent lamps are automatically lighted. A number of conditions must be provided for in such a switch, among others that the incandescent lights may be turned off without relighting the arc lights in the mornings, which is accomplished by a reverse current. Another form of switch is described and illustrated for controlling incandescent lamps in buildings. It enables a large switch to be operated from a distance without the expense of running the main wires along the whole distance.

In the course of a note on the Etna Observatory recently presented by M. H. Faze to the Académie des Sciences (Comptes Rendus, vol. cxxiv, No. 15), says the Electrician, the author refers to the extreme rarity of electrical manifestations on Mt. Etna. In the case of the Casa Inglese, it is doubtful whether lightning has occurred once since 1810. The observatory itself, which is higher than this old hut, has never been struck, although it possesses no lightning rod, and the metal masses of its cupola and zinc roof, neither of which are connected to earth, invite destruction. The absence of lightning does not depend upon the absence of vapor, since in the Alps, where vapor is even rarer, the electrical manifestations are often of an imposing character. In the case of Etna, it may be concluded that protection is afforded by the central crater, whose huge cap of smoke and hot air silently acts as a gigantic lightning guard.

At the annual dinner of the National Telephone Company of Great Britain, held in London the other day, Mr. W. H. Preece, in responding to a toast on "telephony," gave an interesting bit of history anent the early days of the telephone. "Exactly twenty years ago," said he, "the postmaster general of that day commissioned Mr. Fischer and myself to proceed to America for the purpose of inquiring into the invention of a curious instrument that transmitted the voice from one end of the land to the other. He went determined to expose the fraud, but had not been in company of Graham Bell five minutes before he became an ardent believer, and ever since then the apostle of the telephone. Comparing the receiver of to-day with what he brought from the States twenty years ago, there was not very much difference. In extending the use of the telephone in England they had to encourage mutual assistance between the suppliers and the subscribers. The system was growing very rapidly in England, and although the trunk wires had fallen into the hands of the post office, there were more trunk wires being operated in Great Britain than in the whole of Europe."

MISCELLANEOUS NOTES.

The Cincinnati Price Current says: "Our returns show the packing in the West to have been 9,980,000 hogs for the eight months of the summer season ending November 1, and 6,949,000 for the four months of the winter season ending March 1—a total of 16,929,000 for the year, which has been equaled but once previously, in 1890-91, when the total was 17,713,000 hogs. As compared with 1895-96 the late summer season gained 1,785,000, the winter season gained 133,000, and the year 1,918,000. The summer season exceeded any previous year, the nearest approach being 9,540,000 in 1890. The number for the winter season has been equaled or exceeded in five instances."

A dispatch, dated April 8 last, has been received at the Foreign Office from Sir Edmund Monson, Her Majesty's ambassador at Paris, transmitting copy of a report drawn up by the French War Office, respecting the results of the experiment made with aluminum cooking utensils by the troops engaged in Madagascar. The report states that the general results of the experiment were favorable. The chief advantages are unanimously declared to be: 1. Great lightness—a quality much thought of by the experimenters on account of the relief afforded in the matter of transport. 2. Facility in cleaning utensils, which are not subject to rust in any appreciable degree. 3. More rapid cooking of provisions, whence economy of time and fuel. The chief inconvenience attached to an aluminum utensil is that it cannot be soldered. When it is damaged it is useless, cannot be repaired in any way, and must be replaced.

The question has been raised as to whether new or old manure is better to put on land. Taking it ton for ton, new manure has been found as effective as old, also that it loses half its weight by keeping, besides losing some of its nitrogen. Experiments made in Canada last year showed that 8,000 lb. of manure placed under shelter and weighed once a month was reduced to 2,600 lb. between March and December. The manure was at its best at the end of four months, weighing 3,480 lb. The experiments of eight years appear to show that the action between fresh and rotted manure is equal, ton for ton. In England, where the soil is stiff, fresh manure would perhaps be more beneficial, as the soil is lightened by its use, but in Canada, taking into consideration the undigested seeds in fresh manure, the small rainfall, and the outlay in engaging men and horses for daily carting the manure, it would certainly not be economical.—Agricult. Journ., x, 315.

A new process for the protection of iron structures against the injurious action of rust has been suggested by a German chemist, M. Deninger, of Dresden. It consists of treating the iron with a solution of ferrocyanide, which forms a coating of cyanide of iron, uniform and impermeable to water, and of such a nature as to protect effectively the iron covered. The operation, applied on a large scale, is reported to have already given good results. The following is the method adopted in practice: The solution is mixed with a flaxseed varnish to which has been added a little turpentine or benzol, so as to cause a very homogeneous emulsion which can be applied without difficulty. The evaporation of the alcohol leaves the flaxseed varnish, which forms a coat protecting the cyanide of iron which is deposited upon the iron. There is no necessity of previously preparing the iron in any way, beyond removing the beds of rust which are too thick to admit of the action of the ferrocyanide.

Michael G. Mulhall writes in the North American for June as follows: "There is a greater concentration of wealth in the State of New York than elsewhere, the average per inhabitant being 40 per cent. over that of the Union at large. This is partly shown in the prodigious value of house property, including public buildings, which averages \$810 per inhabitant in the State of New York, against \$420 for the whole Union. The six Middle States, taken collectively, give an average of \$660 of house property per inhabitant, which is double the ratio found in Great Britain, and hence it may be affirmed that the people of these States are, on the whole, the best housed community in the world. The average wealth per inhabitant has almost quadrupled in forty years, a marvelous proof of the progress of these States, and unparalleled in Europe; for McCulloch lays it down that only prosperous nations can double their wealth in that interval. The accumulation in the Middle States per inhabitant has been \$10.20 per annum higher than in New England, and exactly double the average accumulation yearly in Great Britain in the interval of 1860–1895. Agricultural wealth forms only 15 per cent. of the total in the Middle States, whereas it is 25 per cent. in the whole of the Union."

A fire broke out on the 17th of May among some loose wood lying under the first-class cruiser Argonaut, now building at the Fairfield Shipbuilding Yard, Govan, says the Practical Engineer. Owing to the strong wind prevailing at the time, the flames speedily obtained a firm hold of the pitch covered teak planking with which the iron frame of the ship is sheathed. The heat of the sun had melted the pitch, and thus rendered the woodwork an easy prey to the flames, which, on the arrival of the fire engines, had spread over the side of the cruiser. After an hour's work the brigade succeeded in checking the progress of the fire. It is impossible to estimate the damage, but the sheathing for about a quarter of the length of the vessel, on both sides, will have to be renewed, and though the flames never penetrated to the inside, it is feared that many of the plates constituting the frame have been damaged by the great heat. The fire originated right under the Argonaut's keel, a few yards aft of the ram, and is supposed to have been caused by a red hot rivet falling among some shavings or other combustible material. The blocks on which the cruiser rested did not appear much damaged, and there is no danger of her falling out of the launching cradle. The Argonaut is a sister ship to the Diadem; she is 467 ft. 6 in. in length, her breadth is 69 ft., and her displacement 11,000 tons. The vessels are all sheathed with teak planking, 4½ in. thick, and covered outside that with copper sheets. The hull of the Argonaut was almost completed, most of the sheathing being in place.

APPARATUS FOR COOLING WATER OF CONDENSATION.

In multiple expansion steam engines used on land it is often impossible to employ condensation, despite the great saving in coal that results therefrom. On board of ships, a continuous current of sea water circulating in the condenser permits of condensing the exhaust steam, while on land the necessary quantity of water is often wanting.

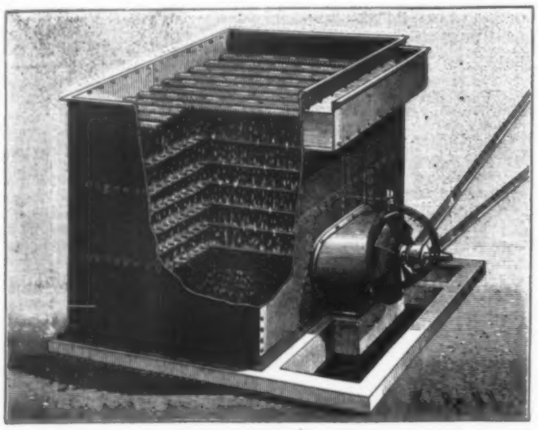
In cities water is very high priced, and in certain regions there is almost none at all to be had for the purpose.

It would be well, then, to have some method of assuring the circulation with a small and limited quantity of water. Were it possible, without sensible loss, to cool the water that has become heated in effecting the condensation of the steam, it might be used anew, just as the water derived from the condensation of steam that has done its work is employed for feeding a boiler. This problem of economical condensation with little water is solved by Chaligny & Company's water of condensation refrigeratory. The apparatus consists of a large iron plate box filled with fagots and resting upon a masonry tank. At one of its sides this box carries a centrifugal ventilator that permits of sending a strong current of air through the fagots, while absorbing but from one to two per cent. of the total power of the engine. At the upper part of the box there is arranged a series of special gutters into which is sent the hot water derived from the circulation or from the condensation. The water overflows from these gutters, is distributed in drops through the fagots of the superposed frames and partially evaporates under the influence of the current of air.

The evaporation thus produced is very feeble, and represents but 18 pounds out of the from 440 to 660 pounds of water necessary for the condensation per horse and per hour. It suffices, moreover, to cool the current of water by about 15 deg. only, which is quite a sufficient reduction of the temperature.

The cooled water, before leaving the tank in which it has been collected, is, owing to a system of partitions and obstructions, obliged to pass through a coke and sponge filter, which purifies it. It may then be sent anew to the condenser.

The applications of these refrigeratories for cooling water of condensation are becoming more and more numerous. They have been installed in stations of electric lighting, in the government arsenals, and upon railways. These apparatus, in fact, supply a want long felt by city industries, and their extremely economical operation explains their success.—La Nature.



APPARATUS FOR COOLING WATER OF CONDENSATION.

GRAVITATION STAMP MILLS FOR QUARTZ CRUSHING.

The magnitude of the gold mining industry of to-day and the enormous possibilities in the near future can only be fully realized by those who carefully analyze the return from the principal fields. The Rand in 1896 produced gold valued at $45,000,000, and the gold fields of Australasia $43,500,000. Then consider the vastness of the mineral resources of the United States, Russia, India, etc. The total world's output was some $425,000,000. This gives some idea what it means to the manufacturer of mining machinery. The magnificent development of modern gold mining is due, in no small degree, to the ceaseless energy of mining engineers, who have evolved an immense industry from what was formely a mere speculation. Nothing has contributed to this change to a greater extent than improvements in machinery for milling the ore and the methods of extracting the metal. Hundreds of mines which, a few years ago, would have been commercially unworkable are at present profitable investments, for the reason that the introduction of each new appliance or method which reduces the cost of production marks an era, inasmuch as it is immediately followed by the opening of mines with a still lower grade ore and the successful working of others whose position formerly made this impossible. The principal constituent of gold-bearing reefs is quartz, and, in order to extract the gold, this quartz has to be stamped to powder. The general arrangement of the ordinary California stamp mill is well known, but we illustrate an improved high speed gravitation stamp mill made from the standard designs of the Sandycroft Foundry Company, of Chester, England.

On the top of the frame is a crank shaft with five cranks at equal angles, each of which is provided with a connecting rod jointed to a cylinder in such a way that, as the crank revolves, the cylinder moves up and down. Within the cylinder is a deep plug or piston, the rod of which passes through the cylinder bottom and constitutes the stem to which the stamp head is attached. A jacket surrounds the cylinder, and at a distance from the bottom is an aperture or port communicating with the jacket space. Another port at the top of the cylinder also makes the cylinder and jacket common to one another. The cylinder below the lower port is filled with liquid; the jacket also contains liquid, and above the liquid is an air space both in the cylinder and in the jacket. When the bottom of the piston closes, the lower port and the cylinder move upward. The piston and stamp head are supported by a body of liquid. If none of this escapes, and the down strokes of the cylinder do not exceed the number which the stamp head could make under the action of gravity, minus the retardation through friction, and if the length of stroke of the stamp head is the same as that of the cylinder, the position of the piston within the cylinder remains constant, and the liquid is practically undisturbed. If, however, the stroke of the stamp head is less than that of the cylinder and the speed of rotation is as before, within practical gravity limits, it follows, when the shoe strikes the die and the cylinder has completed its stroke, that the position of the bottom of the piston is above the cut-off point by an amount equal to the difference of stroke between the stamp head and the cylinder, this space being filled with liquid which has been drawn in from the jacket. On the up stroke of the cylinder this liquid is forced out into the receiver until the cut-off position is reached and the piston is again raised on a liquid medium as before. It is evident that, if the point of pick up occurs before the middle of the stroke, the stamp head will require the same upward velocity as the cylinder. The latter comes to a rest, however, by the action of the crank, while the former is governed by the retarding influences of gravity and friction; so that at the ordinary working speeds the piston will continue its upward motion after the completion of the up stroke of the cylinder by an amount dependent upon the velocity acquired at about mid-stroke. At certain velocities of rotation, when the stamp head commences to fall, the cylinder will have completed a portion of its down stroke, and if the velocity of fall of the cylinder is not less than that due to gravity minus friction, the velocity of fall of the stamp head will be increased by the assisting effect of the friction between the surfaces of the cylinder and piston and also between the rod and the packing, with the result that a very much greater number of drops can be obtained than is possible with the cam arrangement. The liquid used is water, with a sufficient addition of soap for purposes of lubrication and to prevent corrosion. The quantity of water is maintained by the continuous flow from a small supply pump from a fixed tank, inflow and outflow being possible by means of small tubes. One small pump is sufficient for any number of stamps. The upper part of the cylinder above the top port is grooved longitudinally. So, if a stamp head is hung up, the air passes from one side of the piston to the other without resistance.

To provide for the wearing of the shoe and constant lowering of the piston within the cylinder, several cut-off holes are provided, at about one and one-half inch pitch, so that, on the shoe and die wearing to that extent, all that is necessary is to unscrew the next lower plug, thus establishing a new cut-off port one and one-half inch lower than the previous one. It has been found that the piston, closing as it does on a

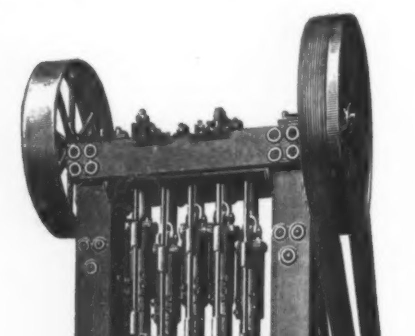


Fig. 1.

Fig. 2.

MORISON'S HIGH SPEED GRAVITATION STAMP MILL.

quantity of liquid, renders the stem so susceptible to rotation that the shoe rarely strikes the die without certain rotary movements resulting, and it is probable that this will be found sufficient in practice to insure the even wearing of the surface of the shoe and die: but, if desired, a very simple system of turning gear can be fitted which works very effectively. There is no trouble experienced by leakage. Experiments made with the high speed stamp mill have been very satisfactory and the results are given in great detail in London Engineering for May 14. We are indebted to this journal for our engraving and the foregoing particulars.

FOSTER'S FILM EVAPORATOR.

THE illustration published herewith represents Foster's patent film evaporator, complete with cataract condenser, vacuum pump, engine and exhaust steam receiver. The following average results have, we are informed, been obtained by this apparatus during an ordinary working day of twelve hours:

Vacuum	26·5 in.
Steam pressure in the exhaust steam receiver	6·5 lb. per in.
Temperature in evaporator	110 deg. Fah.
Temperature of supply liquor	49 deg. Fah.
Specific gravity of supply liquor	1·050
Specific gravity of concentrated liquor	1·152
Temperature of concentrated liquor at discharge	102 deg. Fah.
Temperature of condensed steam	96 deg. Fah.
Water evaporated per square foot of heating surface per hour	13·37 lb.

The heating tubes in the apparatus are each 4 ft. long by 2 in. external diameter, and fitted internally with Foster's patent film tube. A section of one of these is shown in Fig. 1. Each tube is supplied separately with liquor, which is concentrated to the density named above during the time it takes in running from the top to the bottom of the tubes, and is drawn off at the bottom of the apparatus by a pump, so that the operation is continuous, and requires little or no attention after once being started to work.

As will be seen from the illustration, the evaporator is of the ordinary vertical type, the heating tubes being placed in parallel rows, each branch supply pipe supplying two rows of tubes. These supply pipes are connected to a main trunk supply chamber on the side of the evaporator from which they take their supply, and are easily disconnected when the film tubes require to be taken out for cleaning purposes. The top of each film tube is fitted with a liquor spreading or distribution chamber, as shown in Fig. 2, which also shows three views of this—one in section, one of the top or distributing chamber, and one showing the bayonet catch attachment to the tube. This chamber, as will be seen, has three legs or ribs with open spaces between, which rest on the top tube plate, and from which the film tube plate is suspended. The liquor to be evaporated is fed into these chambers, and runs down the annular openings in each of these three legs or ribs, and is then distributed by the shields shown on the film tube on Fig. 2. The annular space between

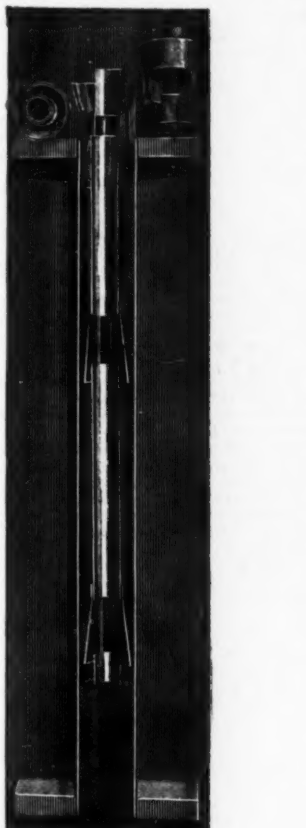


FIG. 2.—EVAPORATING TUBE.

these shields and the heating tube is larger at the top than at the lower end, as there is less water to be evaporated as the liquor gets to the bottom of the tube. Each film tube in this apparatus is fitted with five distributing shields. As the liquor evaporates the vapor passes under these distributing shields and through the openings under the shields, and up through the center of the film tube to the top vapor chamber, and from there to the condenser, the vapor being able to escape under the shields and up through the center of the film tube. The whole evaporating surface of the heating tube is covered with the liquor, which does not run down in rivulets. In order that the vacuum should be the same at the bottom of the tubes as in the top vapor chamber, a large vapor connection is made on the side of the apparatus from the bottom to the top, as shown in the illustration of the complete apparatus. This also takes away any vapor that might accumulate at the bottom of the apparatus.

This system of evaporator is, it is claimed, specially adapted for the rapid concentration of liquors that deteriorate by being exposed to high temperatures for any length of time.

We are indebted to the London Engineer for the cuts and copy.

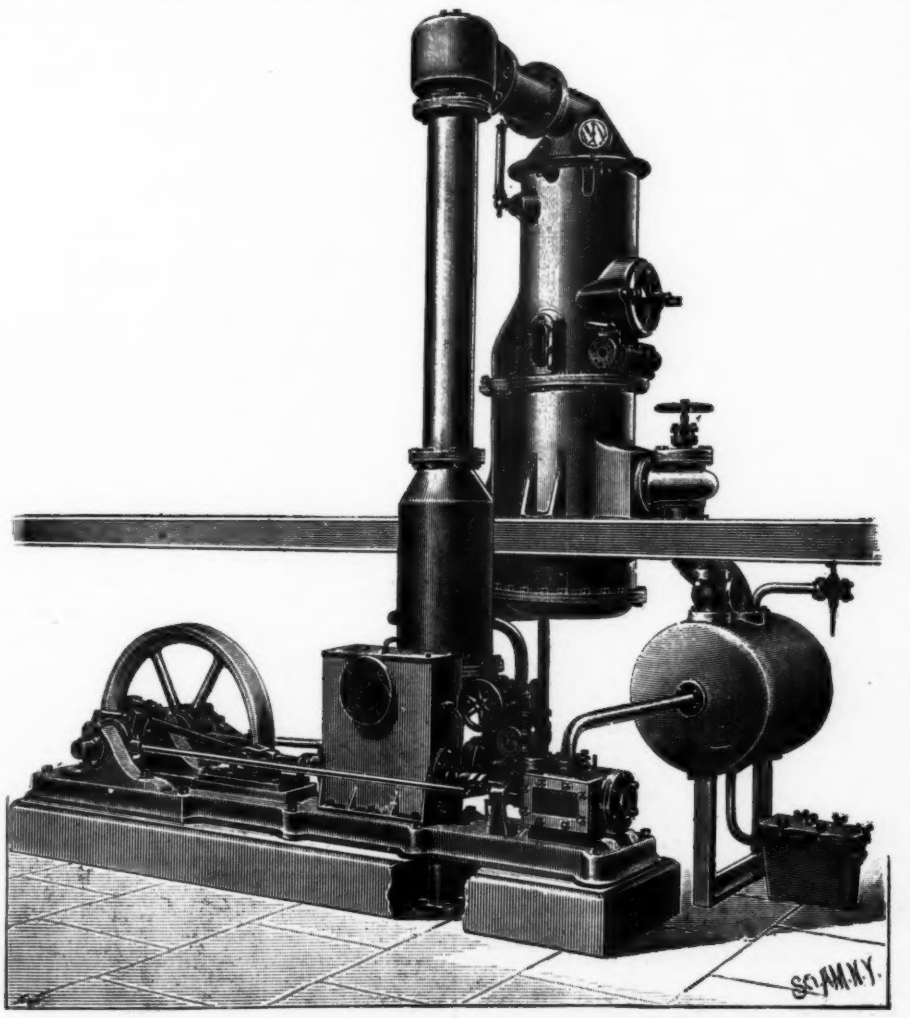


FIG. 1.—FOSTER'S FILM EVAPORATOR.

THE PROGRESS OF GAS ENGINES.

THE leading gas engine maker of England recently made the statement that his total sales had reached the number of 20,000 installations.

Mr. G. C. Truby, chief engineer of the London Gas Light and Coke Company, is authority for the statement that 2,500 gas engines are now at work in the city of London, and reliable information from other sources leads us to place the total number of gas engines in use in Great Britain at fully 35,000. In Germany there are said to be upward of 85,000 gas engines in use. In the United States the number of gas engines installed to date sinks into insignificance when compared with the progress made by these motors in England, Germany and France.

Mr. J. Emerson Dowson, the English inventor, who has given practically constant attention to gas engine development covering a series of years, has made the statement that in Great Britain and Ireland gas engines sold to the close of 1894 represented something like 600,000 indicated horse power, and the value of the gas used from city supply mains at $5,000,000 annually.

Our apathetic condition in gas engine adoption is traceable to two causes: First, until quite recently the makers of these motors have insisted upon securing such large profits that would-be purchasers have been deterred from making the selection. Secondly, until a very recent day, the average price charged for gas throughout the country has appeared too high to enable the user of the gas engine to secure the measure of economy in operation that he seemed to expect, in order to induce him to adopt it.

Both of these objections have been eliminated to a very large degree, since half a hundred makers of gas engines in this country are now bidding against each other, while gas companies generally have come to recognize the value of day consumption, and, as a rule, make a special price for gas used for power. These prevailing conditions then are certainly favorable for anyone wishing to adopt a gas motor.

The best inventive genius and mechanical talent of nearly a century and a half have been directed to the improvement of the steam engine, as against a little over a third of a century of effort put forth on the gas engine. The Lenoir gas motor was the first of the so-called "internal combustion" engines of which there is an authoritative record showing performance of work. This is found in the tests made by Tresca in March, 1861. In these trials Tresca found with a gas consumption of 96 cubic feet he was able to secure but 0·04 per cent. efficiency (B. H. P.) At this time it is a very common experience to find gas engines on consumptions of 16 to 18 cubic feet of gas giving 80 to 85 per cent. mechanical efficiency; the equal in every respect of the steam engine of the highest grade. So eminent an authority as Professor Kennedy states that the steam engine can by no possibility convert into work more than 30 per cent. of the heat energy put into the engine, but that a gas engine may attain an efficiency of at least 80 per cent. Roughly stated, the best type of steam engine in practice converts about 10 per cent. of its theoretical efficiency into work, while the gas engine has already attained nearly 30 per cent. efficiency.

Herr Koerting read a paper on the use of gas motors for the production of electric energy before the Institute of German Gas and Hydraulic Engineers at its June meeting in Berlin. Comparing the efficiency of gas with steam power, Koerting gave the following table:

Steam Engines—		
10 horse power	2·2 per cent. useful effect.	
50 "	4·0 "	"
100 "	6·9 "	"
Illuminating Gas Motors—		
10 horse power	9·1 per cent. useful effect.	
50 "	9·9 "	"
100 "	10·9 "	"
Power Gas Motors—		
10 horse power	7·3 per cent. useful effect.	
50 "	10·2 "	"
100 "	12·9 "	"

Referring to the working results as determined at the electric lighting plant at Hanover, Germany, Mr. Koerting arrived at the conclusion that with steam the cost for amortization and interest was 88,620 marks, with gas only 47,250 marks—a saving in the first cost of nearly 50 per cent.

In no other class of machinery is there a greater discrepancy between the manufacturers' record and the shop exploits than in steam engines.

"It is well known," remarks the Boston Journal of Commerce, "that the effective power of an engine depends entirely upon the average steam pressure within the cylinder and the speed of the piston in lineal feet per minute. When these two points are settled, leaving friction out of the question, the nominal power may be calculated approximately correctly. But here is where the principal difficulty lies. One builder may test an engine of a given size at 40 pounds cylinder pressure and a piston speed of 300 lineal feet per minute, and rate it perhaps at 50 horse power, while another manufacturer with the same size engine may use in his test an average steam pressure of 50 or 60 pounds with a piston speed of 600 feet per minute, and obtain much greater results. Thus, while the two

engines may be substantially the same size, there will be a vast difference in their ratings."

Those unacquainted with the gas engine believe it incapable of performing satisfactory work economically. They, moreover, imagine that it is a long step from the steam engine to a gas motor, and that there are hidden difficulties in the operation of gas engines, veiled to the eye of the purchaser pending sale, but which appear after installation. Of course the thousands of workshops depending wholly or in part upon the gas engine for power refute an assumption of this nature, yet it does exist among timid people who have not given the subject careful investigation—after which the most skeptical would no longer question the capabilities of gas engines. Those who have installed these motors know there are no hidden pitfalls or other obstacles to be surmounted by those adopting gas engines; quite the contrary, for a multitude of uses these motors eclipse in many ways every known power.

It is a mistake to suppose that in adopting a gas engine one is taking "a leap into the dark," for there is not such a wide difference after all in the two forms of motor. "The only essential difference between a steam engine and a gas engine," says a well known writer, "is in the agent used, vapor in one case and air in the other."

In the steam engine the steam presses upon the piston and drives it to accomplish its work. The water from which the steam is made is the product of the chemical union between two gases, oxygen and hydrogen. Hence, each molecule of steam is the result of the union of hydrogen and oxygen; now, in all known artificial gases, except producer gas, hydrogen is present in large quantities, for instance, in coal gas we have 47 to 48 per cent.; in carbureted water gas, 30 to 35 per cent.; in uncarbureted or non-luminous water gas, 45 to 47 per cent., and so on. When these molecules of gas enter the cylinder of a gas engine and the explosion takes place, the same thing happens as when steam is doing its work in that type of motor; millions of molecules are set loose and pound upon the piston and so force it to perform work. "Steam pressure" is simply an incalculable number of infinitesimal molecules liberated from water, which, by a series of little impulsive shocks upon the piston, causes that appliance to produce power.

The steam engine is extremely wasteful; the percentage of energy developed in the best and most approved type of steam engine utilizes but a small fraction of the power value existing in coal. Experienced engineers will tell one that the most efficient motor of this class utilizes only about ten per cent. of the real value of the fuel, while a perfect engine of this type should consume but a fifth of a pound of coal per horse power, whereas those of superior construction, having the most intelligent supervision, in operation demand at least two pounds of coal to maintain a horse power for an hour.

Discussing the question of economy in steamship propulsion before the Marine Engineers' Institute, England, Prof. Weighton lays down two governing considerations, namely, the friction of the mechanism, the maximum horse power and the fuel. As respects the efficiency of modern machinery, he thinks there is little to boast of, enforcing this opinion with the statement that if we reduced one pound of coal to horse power, we would have 327 horse power; and for every pound of coal burned there should be obtained, if the machinery and the boiler and the furnace were all fulfilling their purpose with perfection, 327 horse power, instead of merely 17½ horse power. A unique illustration was given by Prof. Weighton, by means of diagrams representing disks, of the various approximate losses of power from the boiler to the propeller, showing how such losses of power accrued—namely, at the furnace by the radiation of heat, by latent heat, and by heat passing off in the form of oxide. Alluding to the difference between Welsh coal and the Newcastle and Scotch, and the best methods of burning them, the coal required, he said, for 1,000 horse power was thirty-six tons a day, but if the machinery utilized all the latent heat in the fuel, only about two tons would be necessary.

The following results have recently been obtained by M. Allaire with a 50 horse power Charon motor, Bulletin technol. des Ecoles nationales d'Arts et Metiers. Two cylinders, diameter, 14 in.; stroke, 24 in.; speed, 150 revolutions per minute. Trials, 15, from 16 to 53 horse power; power measured by Prony's brake. Temperature of meter, 190° C. (66·2° F.) At different horse powers the following data were found:

Horse Power Utilized.	Horse Power Indicated in the Cylinders.	Gas, Cubic Feet per Horse Power per Hour.	Efficiency of the Motor.
16·3	31·0	30·17	52·6
19·0	33·8	26·17	56·35
21·68	36·41	23·35	59·4
26·9	40.5	19·59	66·5
34·9	46·6	15·70	74·9
40·0	49·5	15·14	81·0
45·2	52·8	14·32	85·5
50·5	56 5	13·87	89·2
53·15	58·3	13·75	91·2

The publication of the results of the trials made by M. Allaire led the French government to take up the matter, and the engineers employed in the experiments have recently made their report, in which they say that, as the result of various experimental trials, gas engines of 25 to 50 horse power consume from 466 to 470 liters, that is, about 16·67 cubic feet per horse power per hour, the gas being measured as at 0° C. and 760 mm. pressure.—The Progressive Age.

Recent petroleum borings in Galicia have brought about very satisfactory results. The annual production amounts at present to some 4,500,000 barrels, but the Schadentgoer Petroleum Company, which owns some of the richest springs, is at present constructing a large refinery at Oderberg, close to the Prussian frontier, with an annual capacity of 500,000 barrels, and the aggregate annual production of Galicia is expected to shortly reach 6,000,000 barrels.

LESSONS FROM AMERICAN RAILROADS AS TO CHEAP TRANSPORTATION.*

By W. R. Stirling, formerly Vice President of the Illinois Steel Company, Chicago, U. S. A.

The comparative cost at which manufacturers can assemble their raw materials and distribute their finished products has necessarily a great deal to do with the success of manufacturing industry in all countries, however different may be their circumstances from other points of view.

This subject has a special interest for the iron and mineral industries, which are of vast extent, and represent a larger volume than any other industries pursued on a gigantic scale.

Wide differences necessarily exist as between countries in which the railways are state-owned and state-controlled, as is mostly the case on the continent of Europe, and countries like the United Kingdom and the United States, where the state does not and cannot well interfere with the ordinary administration of the principal lines.

Differences also exist as between a country like Great Britain, where heavy expenditure has been incurred in the purchase of land and the construction of lines of railway under governmental regulations, and a country like the United States, where the land costs next to nothing, except in the neighborhood of large towns, and where railway companies are to some extent allowed to please themselves as to what they do—and how they do it.

These differences are so material that it becomes difficult to make a comparison that is in any degree relevant and parallel as between the railways of one country and those of another. And yet, unless such a comparison is in some degree attempted, the object aimed at in the presentation of this paper, that, namely, of showing to what extent and how American railways have lowered their rates for transportation, and thereby cheapened the cost of raw material and manufactured commodities, would not be achieved.

CAPITAL COST OF RAILWAYS.

The difference that mainly strikes one who approaches the consideration of the comparative conditions of railway transport in Great Britain and the United States is the much greater cost of the British lines, as tested by the amount of capital actually invested. Comparison of actual cost is, however, extremely difficult, because of the great amount of "water" in both American and British roads. It is a well ascertained fact that the American railroad companies have expended but a part of their nominal capitalization. A recent writer† has pointed out that the different ways resorted to in order that the capital of American railways may be increased include:

The payment of unduly large sums of money for construction.

The purchase of properties at excessive prices.

The purchase of superfluous competing lines.

The sale of bonds and shares at a discount.

The declaration of stock dividends.

The same writer concludes that whereas the total capitalization of American railroads in 1893 was 10,122 millions of dollars, the real capital outlay is not much over 6,840 millions. Mr. Poor, the greatest authority on American railroads, has expressed the opinion that the bona fide investment in railroads does not probably exceed the aggregate of their floating and funded debts, and if this held good the amount of "water" in the American railway system as a whole would be $27,000 per mile, or a total sum of 4,860 million dollars for the 180,000 miles now constructed in the United States. In other words, assuming the substantial accuracy of these figures, the average cost of our American railway system would only be £7,092 per mile, as against the £12,500 per mile at which it stands to-day in the official returns.‡

The importance of these figures obviously lies in the fact that, cheap as American railroad freights are to-day, they do not represent the irreducible minimum of cheapness. On the contrary, had this gigantic system of "water" not been perpetrated, the amount of capital upon which dividends have now to be earned would have been 975 millions sterling less than it is, and to earn 5 per cent. on this sum would call for an income of 46½ millions sterling per annum, which otherwise could have gone in further reductions of freight rates.

I do not propose to carry this part of the subject much further, because, after all, it is more or less speculative, and little is to be gained by a consideration of what might have been. No doubt, the same element of vain regrets, perhaps in a greatly accentuated form, enters into the question of the manner and the character of British railway capitalization. At any rate, your average capitalization for the railways of England and Wales is to-day over £50,000 per mile, which is about four times the inflated capitalization and nearly seven times the bona fide capitalization of American railways. It is impossible to admit that the whole of this capitalization, or anything like it, has been judiciously incurred, although you have in this country parliamentary and other charges that are not entailed upon American lines. Indeed, there appears to be no good reason why British lines should not be constructed, I will not say as cheaply as the average of all American lines, but, at any rate, as economically as, say, the Pennsylvania Railway, which serves a densely populated country, carries an enormous volume of traffic, is maintained at the highest possible point of efficiency, has a magnificent equipment and yet has cost only about £20,000 per mile. I can see nothing to justify in this country an average capital outlay of 150 per cent. in excess of this amount, and there should be solid grounds for supposing that if you had to reconstruct your railway system to-day it should not exceed £20,000 per mile. Assuming this to be the case, you would appear to be burdened with about 500 millions of capital, or fully one-half of the whole, in excess of actual present day requirements, which, taken at 5 per cent., means an annual charge of 25 millions in excess of what should be required to meet all reasonable conditions. This sum, I may further add, is nearly 60 per cent. of your total railway income from goods and mineral traffic, which, but for the existence of such a serious burden, might presumably be carried for less than one-half of the present actual rates at an equal profit.

EQUIPMENT.

We in the United States have a very general impression that the goods and mineral traffic of this country could be carried much more economically if you were to bring up the character of your equipment to something like the American standard, and if you were to do more in the way of adopting American methods as a whole. There is, of course, a wide difference in many of the conditions, which would no doubt prevent perfect approximation.

Our hauls are generally much longer—probably three times as long, on an average—than yours. We have generally adapted our railways and our methods to the use of wagons or cars of large capacity, whereas in this country, as some of your engineers have pointed out, serious and expensive structural changes would be involved in any attempts to introduce large cars and much more powerful locomotives. I am not a railway engineer, and therefore it is no part of my business to point out what is possible and what is impossible in this direction. All I mean to attempt is to show how American traders have had their rates brought down to a point that would have been deemed incredible not so many years ago by improvements in their methods and in their equipment.

Foremost among these changes is the great increase which has taken place in the general size of the cars or wagons made use of for mineral and other traffic. Following British practice in this as in so many other directions, we in the United States began with small wagons of 8 to 10 tons capacity, and this was the standard in general use until the year 1876. Several lines adopted 10 to 12 ton wagons in 1877. About 1881, 20 ton wagons were constructed for the first time, and to-day we see the largest freighters and freight carrying lines adopting wagons, in part constructed of steel, to carry 30 to 35 tons, which is, I believe, about four times as much as the general capacity of the wagons used in this country. I may here add that wagons of 50 tons capacity are to be used to carry the ore traffic from Lake Erie to the Carnegie Company's works, near Pittsburg, over the new line now building, and this traffic is expected, according to Mr. Andrew Carnegie, who is a large shareholder, to yield a sufficient profit with a freight charge of only ¼d. per ton mile.

It will be understood that the great advantage obtained in making use of cars of large capacity is the saving of tare. If it were possible to use cars of 45 tons capacity for all our mineral traffic, we should probably save at least one-half of the tare, which is usually in smaller cars about one-half of the paying load. In other words, it appears to be possible to save one-fourth of the total load carried on British railways by these means. I speak of what has actually been accomplished in the United States, but, as I have already intimated, under different conditions. The subject of whether anything can be done, and what, to adapt British lines to this system is one that I must leave for others, but, so long as the present enormous and unnecessary non-paying weight continues to be carried on British lines, the advantages which we have in the United States from a different system cannot be realized.

Largely as a result of the increase of the average load hauled on American lines, the efficiency of the locomotives in the matter of work accomplished has been largely increased. The locomotives of to-day perform more than twice the work they did twenty years ago, as measured by the test of the number of tons hauled one mile. On the Pennsylvania Railroad the locomotive work increased 143 per cent. within eleven years. The same increase of efficiency appears in the test of train mileage, which, within the same period, showed on the Pennsylvania Railroad an increase of 147 per cent.

Some years ago, when giving testimony on matters relating to the tariff before the United States Senate Finance Committee, I had occasion to refer to the enhanced cost of American iron and steel manufactures because of the cost of transportation. Senator Harris challenged the statement and said he understood that in no country in the world was material more cheaply transported than in the United States. I agreed with his remark so far as it related to the rate of freight per ton, but not so far as it related to the extent of the transportation. The "magnificent distances" of America and the length and cost of transportation therein involved, even at a low freight rate per ton, is an important item in the cost of manufacture.

When I left Great Britain in 1879 for residence in the United States, the railroad freight cars in use in the United States had a capacity of only 10 to 12 tons, the car of that day appearing to be a giant beside the small goods wagon used in Great Britain. In the light of present practice, the car of 1879 is a dwarf beside the 35 ton car of 1897, and when the Carnegie Steel Company shall have in active operation iron ore and coal cars, carrying 100,000 lb. or 50 net tons, the evolution of the freight car in the matter of size will have reached a high stage of development.*

To a man who has been actively engaged in business on both sides of the Atlantic, it must always be interesting to note the wide difference in many particulars between the American and the British methods of railroad operation. On the one hand, in Great Britain, we find expensive, substantial construction, an army of employes to care for the comfort and safety of the passengers, small carriages and goods wagons, a scarcity of box cars, and the substitution of tarpaulins, short trains and frequent service. On the other hand, in America, we see rapid construction, of a less permanent character at the outset; reliance upon the public to take care of themselves; enormous cars, whether for passenger or freight purposes; box cars of mammoth size for the transportation of bulky freight, such as furniture; and trains not infrequently 500 yards long when loaded and 1,000 yards when empty.

Presumably there are good reasons for the practice that prevails on each side. No doubt on many points the conditions of the country, climate, traffic, population, etc., demand different methods. Nevertheless, it

* Paper read at the Annual Conference of the British Iron Trade Association and published in the Iron and Coal Trades Review.

† S. F. Van Oss on American Railroads as Investments.

‡ For details see the Statistical Abstract of the United States for 1835, page 325.

* The Carnegie Company have recently ordered a large number of these cars, and so also with the Pittsburg and Lake Erie Railway.

would seem that the arguments in favor of transporting coarse freight in large quantities in the fewest possible number of cars and at the lowest possible cost would demand a change in British methods and at least a partial adoption of the American.

About 1879 (from which date my personal observations commenced) the average American freight car would carry 24,000 lb. and weighed 20,000 lb., or eight tenths of a pound of dead weight to each pound of paying freight. In 1892 the freight car had developed into one of 60,000 lb. capacity, with 30,000 lb. of dead weight, or five-tenths of a pound dead weight to one pound of paying freight. In 1896, by the use of metal in car construction, it has proved possible to carry 80,000 lb. of freight in a car weighing 27,000 lb. That is to say, in eighteen years, while the capacity of the car has increased from 2½ to 3⅓ times, the dead weight has increased only one-third. It will be readily appreciated by men who are familiar with the detailed costs of transportation how great a saving this means.

Recent trade papers have referred to the steel hopper ore cars now being built for the Carnegie Steel Company to carry iron ore from Lake Erie to Pittsburg, returning with coal from Pittsburg to the lake ports. This is the latest and highest development of transporting coarse freight at a minimum cost, and is made possible by the fact that the Carnegie Company, in conjunction with their railroad associates, have constructed a railroad of a sufficiently substantial character as to its road bed, bridges, etc., to justify and readily support the enormous concentrated load produced by these large cars. As it is well understood that British railroads are much more substantially constructed at the outset, including their bridges, than the average American road in its early days, there should be no difficulty in this country on the score of the road bed and bridges being fit to maintain large loads.

A close analysis of the means by which the American trunk lines are able to profitably transport freight at so much lower rates than the English railroads would require more technical knowledge and greater space than are at the command of the writer. Generally speaking, however, the results are achieved by the application of the following principles, which particularly apply to the handling of iron ore, coal, coke, stone, pig iron, grain, etc.:

1. Efficient and, as far as possible, self-acting appliances for loading a large tonnage in a minimum space of time.

2. Automatic coupling of cars, reducing the number of attendants, and the amount of labor of this kind.

3. Trains of not less than 40 loaded cars of large size or 80 empties, to one locomotive.

4. Dumping or tipping arrangements, or other automatic methods of rapidly unloading an entire train.

5. Utilizing, as far as possible, a large capacity car for varying classes of freight, insuring, whenever possible, a return load.

6. A steady increase in the proportion of paying freight capacity to the non-paying dead weight of the car, with a consequent increase in the proportion of paying load hauled per locomotive. In the language of the report of the "committee on large cars," made to the New York Railroad Club February 20, 1896, the evolution of large capacity cars accomplishes the following desirable results, namely: (a) Reduce the friction and the atmospheric resistance; (b) bring the moving load nearer to the engine, so that it can be more easily handled than in a long train; (c) reduce the empty car movement in the direction contrary to the heavy traffic stream; (d) reduce the number of cars and the number of locomotives for moving a given tonnage; (e) reduce the switching service; (f) reduce the payments for car mileage and the cost of inspection and repairs in proportion to the tonnage moved; (g) increase the traffic capacity of main lines, of freight yards and terminals without building more main tracks and sidings.

As an illustration of some of the foregoing items, the coal traffic from Ohio and Pennsylvania coal fields to Lake Erie ports may be cited. There are in continuous successful operation two or three alternative methods of automatically unloading coal cars of thirty tons capacity almost instantaneously into the hold of the vessels. Either the car is tipped up on an incline, the end automatically opens, and the load slides out, or the car is placed in a cylinder and turned completely upside down, or by drop bottom dumping arrangements it is unloaded into chutes. In the case of coal received at rolling mills, the use of compressed air for instantaneously discharging the load of an entire train of forty or more cars has been partially developed. The importance of coarse freight as an item of traffic and as an item calling for special methods of manipulation in order to cheapen the cost is evidenced by the fact that on nine principal trunk lines, together with 8,400 miles, in Iowa, out of 152,658,240 tons of freight handled in a recent year, 66,289,094 tons, or 44 per cent. of the total, were coal and coke. Mr. R. Quayle, superintendent of motive power and machinery on the Chicago and Northwestern Railway, at a meeting last year stated: "In ore business we have a large number of cars that carry thirty tons, and they are very much more profitable to us than are the 40,000 lb. ore cars. We are now having new ore cars built of the large size. For coal and lumber, such as gondola cars and flat cars, it would seem to me they ought to be built to carry not less than 70,000 lb. It would increase the earning power of the road, and the motive power department would show up to better advantage in the cost of freight hauled per mile. We have been agitating the subject of increasing the tonnage of the cars on this road in the past year, and I think it will result in much good."

In connection with the use of metal in car construction, it may be interesting to note that fifty box and stock cars, with metal underframes, owned by the Chicago, Lake Shore and Eastern Railway, by June, 1896, had traveled, in the aggregate, 4,068,583 miles without costing more than a mere nominal sum, or, say, five dollars per year for the entire maintenance of each car, the metal underframes having required no repairs, except in cases of accident. Furthermore, the Universal Construction Company, of Chicago, an ally of the Illinois Steel Company, in 1896 built some iron ore hopper cars, coal gondola cars, and flat cars entirely of steel, which successfully carried forty tons or more of coarse freight of various kinds. When a shipper in the United States deals with the cost of moving a large quantity of coarse freight any material distance, he can safely calculate on a rate of not exceeding one-half of a cent per ton per mile. If the English shilling be taken as the equivalent of twenty-four American cents, it follows that the rate named is one farthing per ton per mile—a rate, as I understand it, unknown in the United Kingdom.

Mr. Jeremiah Head, in a paper upon American rail and tramways, shows that in 1893 the railways of the United Kingdom earned 3·6 per cent. net upon capital, and the railways of the United States 3·02, the ratio of operating expenses to gross earning being 70·4 per cent. in the United States and 56·6 per cent. in the United Kingdom. It would seem from these figures that the results of these low freight charges in the United States are not altogether satisfactory, but it must be remembered that it is practically impossible to make a fair comparison in the aggregate between the results from 20,000 miles of railroads in the densely populated United Kingdom compared with 177,000 miles, many of them through sparsely populated districts, in the United States. More satisfactory results could, perhaps, be reached by comparing the operating expenses and revenue of the Chicago and Northwestern Railway, with its large iron ore traffic, the Lake Shore and Michigan Southern Railway, with its immense coal, coke, and iron ore traffic, the Chicago and Eastern Illinois, whose main revenue is from coal traffic, with similar railroads in the United Kingdom. Furthermore, the severe lessons of economy taught by the hard times of the last four years, the reduction of wages and number of men employed, the increased use of metal in car construction, the increased efficiency of locomotives, the compulsory use of automatic couplers and air brakes, the steady improvements in road bed, the substitution of stone and metal for wooden bridges and trestles, the resulting increased speed of trains, and, consequently, greater efficiency and earning capacity from the same locomotive power and rolling stock, the decreasing percentage of accidents and consequent decreasing cost of repairs, together with other reasons that need not be enumerated, all combined will unquestionably make it possible in the future to transport freight in large bulk with profit at lower rates than have yet been established. If, by the use of metal cars, thirty cars carrying forty tons each can displace forty wooden cars carrying thirty tons each, it will readily be seen that the saving in wheels, axles, brasses, springs, couplers, doors, brakes, etc., to be maintained, and in oiling, inspection, switching, tracing, clerical and other work, together with the decrease in wheel and flange wear, space occupied in yards, tracks, etc, and other economies too numerous to mention, will make it possible for American railroads in the future to earn dividends at rates that in the past have been unprofitable.

EXTENT AND DENSITY OF TRAFFIC.

It need hardly be pointed out that in transportation, as in other business, economy of working is affected, if not controlled, by the scale on which operations are carried on. The density of traffic is much greater in England than in any other country, and so also with the average gross receipts per mile of line open, which present a remarkable contrast to the conditions which prevail in the United States. The following figures may be quoted by way of illustrating this point:

	United Kingdom. 1880.	1894.	United States. 1880.	1894.
Miles open.......... ..	18,530	21,174	87,762	175,508
Tons carried (1=1,000)..	266,381	334,230	290,897	638,186
Gross receipts (£1=1,000)	37,670	85,922	83,229	217,000
Tons mileage, per mile..	——	——	——	——
Gross receipts "	£2,033	3,844	948	1,240
Net " "	1,685	1,800	——	370

It is evident that the gross and net receipts from traffic in the United States is much less than is the case in Great Britain. Here you averaged about 16,000 tons of mineral and goods traffic per mile of line open. In the United States we only averaged in 1894 about 3,700 tons per open mile, so that the density here would appear to be more than three times what it is there. When this fact is collated with the very much lower rates in force in the United States, it explains the fact that our gross receipts are less than three times those that are earned in this country per mile of line. Of course, we have, in some districts and on some lines, much denser traffic than we have on others. On the lines that traverse the Middle and Eastern States, and on the Pennsylvania lines more particularly, the traffic is especially dense; but, generally speaking, we have to be satisfied with a small gross and a relatively much smaller net income, and we have been compelled, in consequence, to study the utmost economy in working and reparation, while in this country, with your aristocratic ideas and vested interests, and chartered monopolies, you have been able to keep up your rates, and have seen your property improving from year to year. We in the United States would hardly know what to do with our gains if we had your magnificent net railway income of £1,800 per mile—an income which, although net, is 45 per cent. above our gross income. With such favorable conditions, one may imagine the possibility of American lines carrying for next to nothing and offering premiums to freighters.

AMERICAN RAILROAD ECONOMIES.

One of the greatest secrets of the cheap transport which we enjoy in the United States is the economies that have of late years been forced upon our railroads by the exigencies of competition and the demands for cheap service. These economies have now become stereotyped, and a matter of everyday habit. We cannot, as you do in this country, afford to build many different types of locomotives, regardless of cost. We have, as you know, only a few types, so that duplication becomes easy and inexpensive. We have numerous associations whose aim it is to study, and compare experiences upon, the best and most economical types of different descriptions of rolling stock, and hence we have standard cars and vehicles of all kinds, sanctioned by organizations which have made the best conditions their special study. We have economized in material, in train service, in engine service, in road repairs, in bridge repairs, in engine and car repairs, in general expenditure. We have achieved a considerable amount of economy by combinations under one administration of a number of different and often previously competing roads. I greatly fear that in this country the same necessity has not existed for adopting economical methods, and hence the railways are worked on the lordly and magnificent ideas which prevailed when our average ton mile rate was nearer 2d. than the 1c. figure at which it now stands.

RATES AND PROFITS.

Competition on the one hand, and the necessities of particular localities or branches of traffic on the other, have compelled American railways during the last twenty years to bring about a great revolution in their system of charges and profits, while the economies in methods of working already referred to have enabled them to do this, and speaking generally, to still survive. The general range of rates, working expenses, and net earnings per ton mile up to 1880 may be indicated by the experience of one of our leading and most stable lines—the New York Central—as set out in the following table:

Years.	Per ton per mile. Gross earnings. Pence.	Working expenses. Pence.	Net profits. Pence.
1854........	1·47	0·65	0·82
1860.......	1·03	0·67	0·36
1870........	0·92	0·58	0·34
1880........	0·43	0·27	0·16

This has been a typical and not an exceptional experience. It is confirmed by the testimony of many other railroads, for one of which—the Lake Shore and Michigan Southern—the average ton mile rates and the average cost per ton per mile are exhibited in graphic form below. This diagram shows that in 1893 the line named was carrying all descriptions of freight, and not minerals only, at an average ton mile rate of 0·587c., which corresponds to about 0·29d. per ton mile, and as the cost of the service was 0·461c., or 0·23d. per ton mile, it would appear that the net profit was not more than 0·06d. per ton mile. On the Pennsylvania Railroad, which in America corresponds to your London and Northwestern, the average per ton mile for a number of years past has been about a farthing, or less, and the profits have been less than one-tenth of a penny.

While these are exceptional cases, they represent what seems likely before long to become general and inevitable practice, except in cases where railroads are remote and unaffected by competition. Already, indeed, the average American ton mile rate on all railroads and for all descriptions of traffic is about 0·42d., which is, if I am rightly informed, a rate that is rarely quoted in this country even for mineral traffic on a large scale. The net profit earned by our railroads in 1880, small though it was then deemed to be, may become the gross charge of a not far distant period, as it is already over a tolerably large area of mineral operations.

It is not, I apprehend, expected that we should discuss here the question whether these low rates pay the railroads. Frankly, it must be admitted that in many cases they do not, and that railroads cannot in a large number of cases afford to carry for such small remuneration. But so neither in a large number of cases can the traders afford to pay the high rates required by railroad companies in this and other countries, and both traders and railroads are yielding more or less to the law of necessity or compulsion. Happily for the railroads of this country, but unhappily for the traders, such necessity is not forced upon them as a rule. Hence the fact that you have, as traders, to pay very much more, as a rule, than the cost of the service; and hence, also, the fact that your railways are enabled to make profits that would be looked upon as princely even in such legitimate manufacturing businesses as those in which we are engaged as iron and steel manufacturers.

The application, if it is intended to apply them, of the data I have laid before you, will, of course, not rest with me. I have done what I could to present, in a brief and summary form, the leading economic facts affecting our system of railway transport in the States. Perhaps that system has been less studied in this country than it deserved to be. Its merits or demerits, whatever they may be, should certainly be known to the members of the British Iron Trade Association, who are already affected by the competition of American iron and steel manufacturers, which that system aids in making possible, and whose future prosperity must greatly depend upon the extent to which they can secure the advantages of cheaper transport.

Postscript.—Since writing the above I have had occasion to make journeys through England, Scotland and France, and I have had the impressions already formed as to the differences in the equipment of the United States railroads and those of Europe considerably strengthened.

A locomotive driver at Coatbridge informed me that his regular load was 39 coal wagons of 8 tons each, or a total of only 312 tons per train. I noted also on one of the leading Scotch lines that cattle cars only carry 5 tons, while the tare is not less than 6 tons 15 cwt., and I have frequently seen trains with only 13 to 27 cars each—loaded, empty, and mixed. Coal cars, again, or what we in America term "gondola" cars, are marked to carry only 7 or 8 tons each, while they weigh from 4 tons 1 cwt. up to 5 tons 15 cwt. While traveling through France a few weeks ago I noticed that the French cars are better proportioned in size and tare weight than those used in England. In cars which carry a load of 10,000 kilogrammes, or 10 metrical tons, the tare is not more than 5,800 kilogrammes, or a little over 5¾ metrical tons, so that the percentage of the total load in the tare is only 33 to 36 per cent., while the English cars run from 38 to 40 per cent., and those used on the railroads of the United States 30 per cent. or under. I observe, moreover, that the French railroads use much more metal in car construction. The P., L. and M. Railway have some capital, well built, simple metal underframes and upright metal work for their box cars.

THE annual report of Librarian Spofford puts the number of books in the Library of Congress at 748,115, an increase of 16,674 for the year. The library contains 245,000 pamphlets. During the year there were 72,470 new copyrights—an increase of 4,898, mainly attributable to the extension of the international copyright system.

FUEL ENERGY INTO ELECTRICAL ENERGY.

THE following article was contributed by Elihu Thomson to the Electrical World:

Notwithstanding the fact that in these days of long distance transmissions at high voltages the energy of large water powers will become more available, and also in spite of the fact that the fuel cost constitutes, in many cases, not more than 12 to 15 per cent. of the total cost attending electric distribution from stations, the problem of how to obtain an increased efficiency or a greater percentage of the potential work of a fuel as electric energy loses none of its interest. In localities where coal is cheap the actual fuel cost in the working of a plant may be such a small percentage of the total cost in interest, wear and tear, administration, supplies, renewals, etc., as not to be worth considering, since if even 100 per cent. conversion could be attained from fuel to current the saving would be almost negligible.

It is certain also that if in obtaining any increase of yield the outlay for additional plant, or for more costly plant, or for maintenance and attendance, is such as to give rise to an increased charge of but a moderate percentage over the present costs, there would be a neutralization of benefits. Despite, then, the interest which the working out of any problem naturally has for the scientist and engineer, it remains a fact that any new plan or proposal for increasing the percentage of fuel energy rendered available must, to be commercial, accomplish its results within such limits of cost and outlay as will depend on the cost of fuel in the particular locality where the plant is to operate. By the use of triple compound condensing engines at full load 1 horse power hour may be developed at an expenditure of fuel of less than 1½ pounds of coal, a figure which is so low that in any locality where coal can be had for less than $5 per ton it places the actual cost for full load conditions on a favorable basis as compared with other outlays in the working of an electric plant. Indeed, the question of uneven loads and peaks in the load becomes then one of far greater commercial importance than saving of fuel alone, when the plant is working at its best, for the great waste of fuel comes in putting boilers into and out of service, while a large engine but lightly loaded is itself a wasteful piece of machinery. Any plan of fuel saving which, while providing for a given output, is not flexible, or which does not lend itself easily to a system of storage, might have all its value neutralized in consequence. Much has been said from time to time concerning the advantages of gas or oil engines as prime movers, and it is certain that their efficiency of conversion may easily rise to 20 per cent. of the energy value of the gas or oil supplied.

Even in quite moderate sized engines, such as those of 30 horse power and under, one brake horse power hour has been produced for less than ¾ pound of anthracite coal made into gas by one or other of the producer methods, while in oil engines of gas engine type the oil consumption is, even for quite small engines, about 1 pound per brake horse power hour. There is reason to believe that with the work which is being done in improving the engines and producing gas under most economical conditions, with fair sized engines, power may be generated on the basis of about ½ pound of coal or oil per brake horse power, or possibly somewhat better in the case of the oil, owing to its relatively high calorific value. There can be no question about the advantages which such fuel engines have in not requiring any consumption of fuel until they are started. Similarly, when stopped, fuel consumption stops. For a given horse power outfit, however, the gas engines are probably more expensive as to first cost, while they require attention from time to time, as in cleaning, etc., which is not the case ordinarily with steam engines. The attention to boilers required in a steam plant might be offset in part at least by the care of a gas producing and storing plant. Strong objections, both to gas and steam engine plants of large size in cities, arise from the almost unavoidable tremor or vibration communicated to surrounding buildings. This fact has of itself led to the adoption of the Parsons steam turbine in a station in London, and may have a like effect in other places.

Whether a gas or steam engine be employed as a source of mechanical power, the conversion of the potential energy of the combustible into electric energy is not direct, but is made through the heat of combustion conferring kinetic energy on a mass of gas, which energy is partly converted into mass movement or mechanical energy, the piston being driven thereby. Similarly the many attempts to employ the thermoelectric principle rely upon an indirect conversion, but in this case there are no moving parts and the mechanical energy stage is missing. The heating of junctions of dissimilar metals in a thermoelectric series and the production of currents of electricity thereby seems at first the ideal of simplicity and practicability, but unfortunately, despite many most noteworthy efforts to improve the thermoelectric pile, its efficiency remains very low.

It is doubtful whether a better economy than 1 per cent. of the energy of the fuel, delivered to the outside circuit of the pile, can be attained even with the latest and best constructions. The actual construction and working of the piles themselves, as well as their permanency, have undergone great improvement in recent years, but there remains the fact that of the total heat conducted from the hot to the cold junctions but a very small percentage is converted, or convertible perhaps, into electric energy. The pyroelectric generator of Edison would naturally be open to the same serious objection of insignificant yield. The remaining type of apparatus for effecting the conversion in question is that in which the fuel or carbon is dissolved, as is the zinc in a battery cell, while air or some other oxidizing agent acts as a depolarizer.

Many years ago Jablochkoff devised a hot battery in which nitrate of potassium or niter was fused in an iron pot which was made one pole or terminal, and a carbon stick dipped into the fused niter was the other pole. Violent reaction occurred, due to the oxygen of the niter attacking in its hot state the carbon piece, while a fitful current of small energy value relatively to the activity of chemical reaction going on was noticed to flow in a circuit from the pot to the carbon.

Recently the battery of Dr. Jacques has commanded considerable attention. It would seem that in this battery there is in fact an actual quiet consumption of carbon without real combustion. The bath of melted sodium hydrate contained in an iron cylinder has bubbles of air passed up through it, from which oxygen is taken up. The carbon rod immersed in the soda bath is gradually oxidized and a current obtained which leaves the carbon in the bath to go to the iron-containing vessel and through an outside circuit from the iron to the carbon. It is claimed that as high as 85 per cent. of the energy represented by the solid carbon is thus converted into electrical energy available for use.

There are, of course, difficulties, and perhaps the chief one is the carbonating of the sodium hydrate. Unless a bath can be found which does not form carbonate, and which therefore permits the free escape of carbonic acid gas, this difficulty might indeed be fatal.

The handling of fused alkalies is not as easy as might be desired and the renewal of carbons in the battery cells is of course an objection, while the contacts to be provided for large currents passing from cell to cell through hundreds of cells appear indeed formidable. The Jacques battery also will require specially pure fuel moulded carbons, so as to be of proper form and a good conductor of electricity.

In view of all this the central station manager need not, for the present at least, fear having to throw aside his boiler and engines. There does not at present loom upon the electrical horizon any such formidable competitor of the ordinary modes of generating electricity from fuel as need give him uneasiness about the value of his present plant or give rise to any roseate visions of increased earnings due to the substitution of some new mode of generation. The smoothing out of the hills and hollows in the load diagram is apparently of more real importance in his case than systems which would double or triple the present coal efficiency, by which is meant the percentage of energy value of the fuel converted into electric current energy.

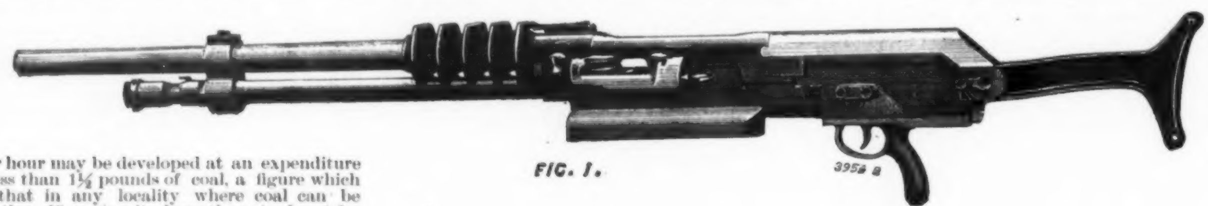


FIG. 1.

FIG. 2

THE HOTCHKISS AUTOMATIC MACHINE GUN.

THE HOTCHKISS AUTOMATIC MACHINE GUN.

IN London Engineering of April 16 and April 23, 1897, there is an interesting description of a new machine gun which is being introduced by the Hotchkiss Ordnance Company, of London, and a test which was made of this gun. We are indebted to this journal for the illustrations and particulars. The weapon is an automatic firing gun, that is to say, it will continue to discharge bullets as long as the trigger is held back and cartridges are fed to the machine. The cartridges are placed in a brass rack or slide which holds a given number of rounds, perhaps two dozen or more. This takes the place of the belt in other guns of this nature. Automatic firing is not caused by the recoil of the barrel, but by an escape of powder gases into a long cylinder or barrel lying parallel with and under the firing barrel. There is a communicating passage between the two barrels within a few inches of the muzzle, and the pressure caused by the explosion of the cartridge passes through this part and presses on a piston or ram which fits into the cylinder. There is a stout spiral spring at the back of the ram, and this is compressed by the pressure of the powder gases. When the bullet has passed out the gas pressure is released and the spring by its reaction carries the ram back to its original position. A reciprocatory action is thus obtained, the range of motion being about six inches. By a series of cams and catches attached to a prolongation of the ram the various movements needful for drawing the slide forward, putting the cartridge into position, firing it and then ejecting the spent cartridge are performed. It is said that the rate at which the gun is fired has been as high as 600 or even 700 rounds per minute, but no attempt was made to reach this rapidity at the recent trial which occurred at Crayford Ness. Three hundred or 400 rounds were fired with success, but toward the end of the experiment a cartridge tilted and jammed in the breech. It was several minutes before it could be extracted; so it spoilt the time records as to the rate of firing. The chief claim to favorable attention made for this gun appears to be its simplicity and the fewness of the parts. There are but 31 pieces all told in the weapon itself. The absence of a water jacket is in its favor. How long the gun can be fired without the barrel becoming unduly hot and how long the life of the barrel is shortened by the higher temperature is a question that experience alone can determine. We will now give a detailed description of the gun.

Fig. 1 is a perspective view of the gun with radiator as we saw it fired on April 12. Fig. 2 is a gun on a tripod mount, but without the radiator. Fig. 3 is a longitudinal section of the gun without radiator, and Fig. 4 a plan of the same. Figs. 5 to 17 are perspective views of the component parts of the gun shown separately. Fig. 18 illustrates the brass feed strip charged with cartridges, and Fig. 19 the strip without cartridges.

As will be seen from Figs. 1 and 2, the gun has a single barrel, which screws into the front of the receiver containing the operating mechanism, as is plainly shown by the longitudinal section, Fig. 3. The barrel, shown separately in Fig. 5, is lettered A in Fig. 3. The automatic action is secured by the cylinder marked C in Fig. 3, and shown separately in Fig. 8, being in communication with the barrel by means of the port, c. Fitting in the cylinder is an elongated piston, F (also Fig. 12), on which are formed cams, of which cams f^1 acts on the breech block, h (also Fig. 10), and the firing mechanism, while the feed mechanism is operated by the cam, f^2. These will be again referred to later in the description of the action of the gun. When the bullet has passed the connecting port, c, the pressure generated by the explosion of the cartridge enters the cylinder in front of the piston, and thus presses the latter toward the rear of the gun, where it is held by the sear, f. When the piston is forced back, it compresses the spiral spring, M (also Fig. 17), and on releasing the sear by pressing the trigger, N (also Fig. 16), this piston is again forced forward by the spring to its original position. So long as the trigger is pressed back, the sear is kept clear of the piston, and the reciprocating action of the latter is unchecked, it being forced backward and forward with a reciprocating motion by alternating forces of the superior pressure of the powder gases and the reaction

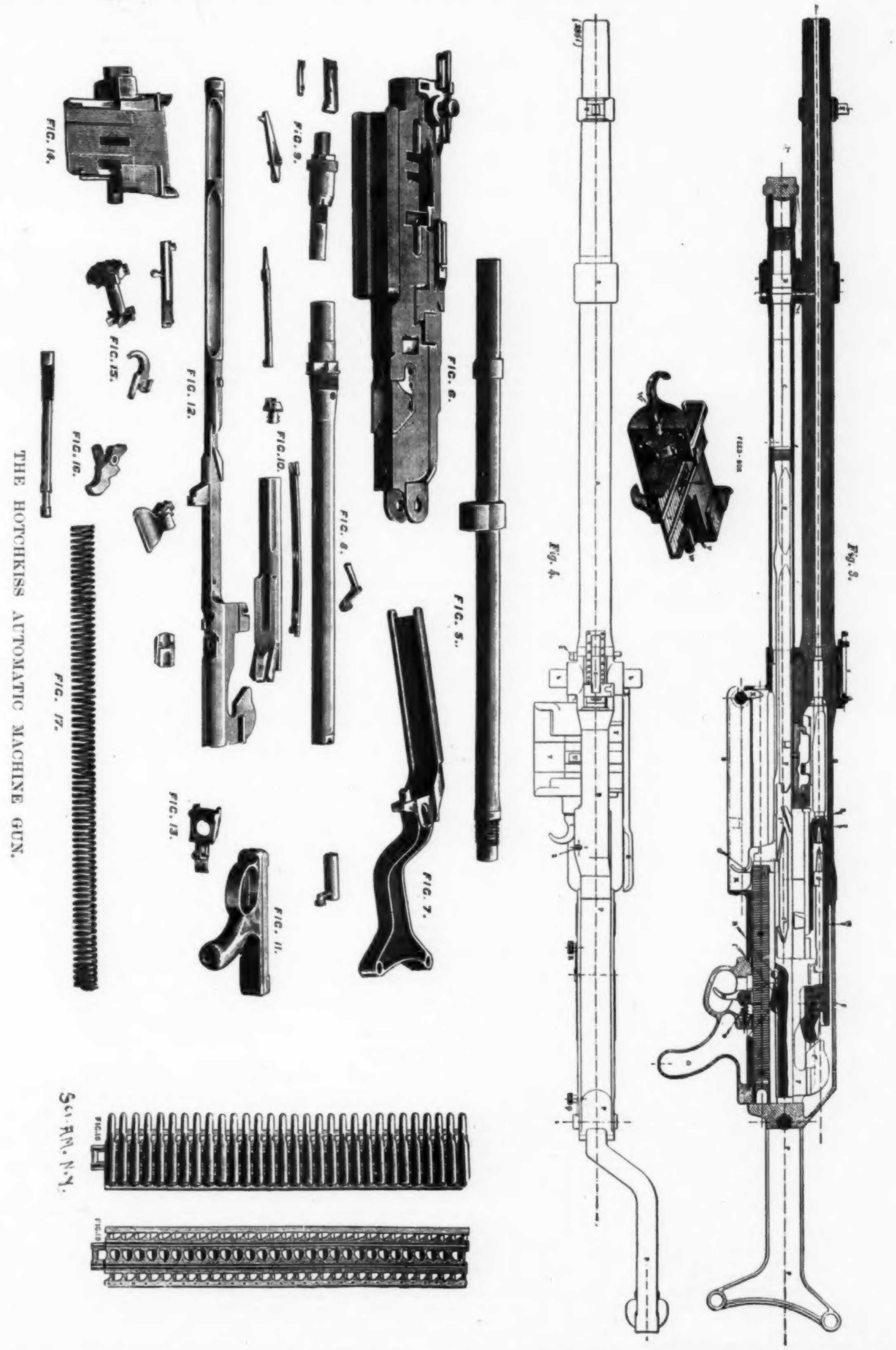
of the spring when the pressure of the powder gases is released. There is a small spiral spring, n, which forces the trigger forward when the latter is released. The piston engages with the breech block, H, and its action may be briefly described as follows: It pushes the cartridge into the chamber, closes the breech, and fires the gun. It opens the breech, extracts the fired cartridge case, and brings a fresh cartridge to the loading position. These operations will be more fully described presently. The cartridges are packed in flat brass strips shown in Figs. 18 and 19. The feed mechanism consists of a feed wheel, U, Fig. 4 (also Fig. 15), which is rotated by means of cams cut in the piston, and engages with openings cut in the feed strip, thus moving the latter through the gun and carrying the cartridge into position. Each backward and forward motion of the piston brings a fresh cartridge in line with the chamber ready to be pushed home by the breech block and fired.

Two men are required to work the gun quickly, one to load and the other to fire, but in case of necessity one man can carry out the whole of the operations. By means of the shoulder piece the man in the firing position at the tripod can aim and fire as easily as he could fire a rifle from a rest.

Having noticed the main features of the gun, we will now proceed to describe the action of the mechanism. It should be stated that the Hotchkiss Company issue an excellent handbook, from which our illustrations are taken, and which we have largely used in preparing our description, although we have seen the gun taken to pieces. Assuming the breech to be closed, the gun is loaded by pushing horizontally a feed strip with cartridges into the feed block. The feed block is well shown in Fig. 1; it is marked T in Figs. 3 and 4, and is shown separately in Fig. 14, and also between Figs. 3 and 4. As already stated, the openings in the feed strip, Fig. 19, engage with the teeth of the feed wheel, U, Fig. 4, which is secured for the present by a pawl, w, shown in Fig. 15, engaging with the ratchet on the feed wheel. The first cartridge is thus held in position preparatory to the operation which brings it in line with the chamber and frees it from the feed strip. A stop, V, which arrests the piston at the end of its backward motion, is pressed down by the feed strip, and so thrown out of action. The gun is now cocked for the first shot by drawing the piston to the rear by means of the finger piece, G. This compresses the main spring, M, and at the same time causes the feed cam, f^2, which is cut in the stem of the piston, to engage between two teeth of the feed wheel. In the meantime the locking dog, h, on the breech block, H (also Fig. 10), has been lifted by the unlocking cam formed on the body of the piston, and the breech block has been withdrawn, the trigger is engaged with the sear, and the piston being held in its backward position, the gun is ready for firing. When the trigger is pulled back the piston is released, and is forced forward by the reaction of the main spring. It carries with it the breech block, and this in moving forward pushes a cartridge out of the feed strip into the chamber. When the cartridge is home the locking cam, f^1, on the piston, brings the locking dog, h, on the breech block to bear against the recoil blocks in the receiver, B. The breech is now closed and locked, and the firing pin, J, is driven against the primer by the tang on the piston, and the cartridge is thus fired.

The next set of operations are caused by the rearward motion of the piston under the impulse of the powder gases. The breech block, H, is drawn back, and the extractor, K, withdraws and ejects the empty cartridge case. The piston is then held by the trigger, the main spring being compressed, and the gun is ready for the next shot. That is for single shots; for continuous firing the trigger has to be held back by the finger of the operator. The teeth of the feed wheel, U (also Fig. 15), being engaged in the cam, f^2, cut in the piston stem, each backward motion of the piston turns it one tooth, and draws the feed strip forward, thus bringing another cartridge to the loading position. When the feed strip is exhausted, the stop, V, which is held down by it, rises, and holds the piston in its backward position independently of the trigger.

The advantages claimed for the gun are its simplicity,



THE HOTCHKISS AUTOMATIC MACHINE GUN.

positive feed mechanism, safety, accuracy of fire, and not being affected by heat. In regard to the first of these claims, the gun consists of only 31 parts, exclusive of sights. There are no screws or small pins, and but four springs, the main spring, however, alone being absolutely essential to the working of the gun. The parts are so designed that it is impossible to assemble the gun incorrectly, and for dismounting or assembling the gun no tools are necessary, except a spanner. It is also claimed that by loading with feed strips the officer has better control over the rate of fire and expenditure of ammunition than is possible with belts and drums. This is a claim the advantage of which will, no doubt, be contested. Safety is secured, it is stated, from the following causes. No accident can occur through a hang-fire cartridge, because the mechanism being actuated by the gas pressure, the breech remains closed and locked until the gun is fired. The breech cannot open until the bullet has left the muzzle, because the locking dog and breech block are operated by the piston alone, and the latter only begins its backward motion when the bullet has passed the port and has admitted gas to the cylinder. The cartridges are fired as soon as pushed into the chamber, and are kept away from any heated part until the instant of firing. The gun is not affected by the heating of the barrel, as all the moving parts of the mechanism are independent of the barrel. In regard to accuracy it is claimed that the mechanism being rectilinear in its motion and symmetrically disposed with reference to the trunnions (shown at b, b, Fig. 4, and also Fig. 6), which take up all recoil and vibration, the aim is not deranged by firing.

Several types of mountings for this gun have been made, both for field, mountain, and naval service. For land service it is generally used with a folding tripod, and transported on pack saddles.

The following are the weights given :

	Lb.
Saddlery, waterproof cover, etc.	66
Gun	33
Tripod	28·6
Chest with accessories	22
Two chests with 600 cartridges	63·8
Total	213·4

For convenience of reference, we give a list of the parts, with the lettering adopted in Figs. 3 and 4, and also reference to the separate perspective views :

Barrel, A, and Fig. 5	With cylinder collar, a, for supporting front end of cylinder.
Receiver, B, and Fig. 6	With trunnions, b, b, and seat for rear sight.
Cylinder, C, and Fig. 8	In connection with barrel through port, c.
Regulator, D, and Fig. 9	For varying capacity of cylinder chamber and consequent pressure on piston head.
Securing key, E, and Fig. 9	For barrel and cylinder.
Piston, F, and Fig. 12	Consisting of body with sear, f, and cams, f', for operating breech block, and stem with cams, f², for imparting intermittent motion to feed wheel.
Finger piece, G, and Fig. 15	For cocking piston by hand for first shot or in case of misfire.
Breech block, H, and Fig. 10	With locking dog, h.
Nose piece, I, and Fig. 10	Supporting base of cartridge.
Firing pin, J, and Fig. 10	Actuated by tang on body of piston.
Extractor, K	Mounted on breech block, and securing nose piece.
Ejector, L	Journaled to receiver and actuated by breech block.
Main spring, M, and Fig. 17	For throwing piston forward.
Trigger, N, and Fig. 16	With trigger spring, n.
Pistol grip, O, and Fig. 11	With guard.
Shoulder piece, P, and Fig. 7	With breech cover, p.
Breech cover pin, Q	Fixing shoulder piece and breech cover to receiver.
Safety lock, R	Preventing movement of piston.
FEED MECHANISM,	SELF-CONTAINED.
Feed block, T, and Fig. 14	Containing the feed mechanism and forming a guide for the feed strips.
Feed wheel, U, and Fig. 15	For moving the feed strips and thus bringing each cartridge in front of chamber.
Stop, V	With stop spring, v, for arresting piston at end of its backward course independently of trigger.
Feed arbor, W	With pawl, w, engaging in ratchet on feed wheel and pawl spring.
Foresight, Y	
Rear sight, Z	

The possibility of dynamite or blasting gelatine becoming influenced by heat increases with the number of constituents that enter into its composition, according to Mr. Oscar Guttmann, in the London Engineer. Although it may be thought that in dynamite the nitro-glycerine only has to be taken into consideration, yet it was found some twelve years ago that with perfectly good nitro-glycerine and what was apparently excellent kieselguhr, a good dynamite could not be made. On examination it was shown that the kieselguhr contained, besides traces of iron and charred organic matter from calcining, comparatively large amounts of aluminum sulphate. Even a small quantity of this proved to have a decomposing action on the nitro-glycerine, with the consequent development of nitric peroxide.

THE PRACTICE OF THE COMBINED OPEN HEARTH PROCESS OF MESSRS. BERTRAND & THIEL.*

By E. Bertrand.

Before proceeding, I beg leave to make a short statement regarding the essence and origin of the process, which is practically based upon the principle of dividing the work heretofore done in one furnace alone between two, or eventually three furnaces, and of perfectly separating the resulting phosphoric and siliceous slags from the metal as it passes from one furnace to the other.

The steel works at Kladno have, besides their basic Bessemer plant, a limited basic open hearth plant, consisting of one furnace of 12 tons and one of 22 to 24 tons capacity, for the purpose of working up the scrap and crop ends resulting in the works. The former of these furnaces was erected upon the same level as the gas furnaces for melting or heating the pig iron for the basic Bessemer process, since it was intended to use it as occasion demanded also for this latter purpose. It is, therefore, situated upon a level of about 15 feet higher than the larger open hearth furnace.

Experience showed that, when working with a more siliceous and phosphoric pig iron, the heats absorbed considerably more time toward the finishing of the heat, owing to the necessity of adding much more lime for the neutralization of the resulting more phosphoric and siliceous slags, as it took more time to free the metal effectually from the phosphorus.

The position of the two furnaces upon different levels naturally led to the idea of dividing the work between these two in such a way that the upper furnace should eliminate the main bulk of the silicon and phosphorus, while the lower one should perform the finer work of finishing the metal, which may be done far more effectually and with greater accuracy when the highly siliceous and phosphoric slags resulting in the upper furnace are perfectly separated from the metal on its way to the lower furnace.

Since a perfect elimination of the phosphorus is not intended in the upper primary furnace, less lime may be added than would be otherwise necessary, and the quantity of slag to be melted therefore materially diminished.

The slag covering the metal in a thinner sheet also permits the flame to act with greater intensity upon the metal.

The plan of working that was subsequently adopted in this combined way with two furnaces consisted in charging nearly all the siliceous and phosphoric pig iron into the primary furnace, and nearly all the scrap into the finishing furnace, adding in each such quantities of ore, lime, etc., as the circumstances and experience demanded.

The advantages gained thereby in comparison to the former method of working separately in each furnace resulted in an increase of output and a material reduction in the consumption of lime and of basic materials for lining the furnace hearths, since the diminished quantities of slag and their more perfect neutralization naturally reduced the corrosive action of the slags in the furnace. A saving of fuel must also have taken place in proportion to the increased output, but this could not be proved, because all the gas furnaces of the whole plant are fed from the same group of producers.

A further material advantage consisted in the possibility of being able to work either with a much higher proportion of pig iron, or even with pig iron alone, or to use as addition to the scrap, pig iron very high in phosphorus, no matter if gray or white, i. e., high or low in silicon, without altering the final result, as long as the pig iron was free from sulphur. Working with more pig iron and ore, a reduction of the loss resulted owing to the reducing action of the carbon, silicon and phosphorus in the pig iron. I refrain from giving figures regarding the above statements, as they have been previously published in the paper of Mr. Joseph Hartshorne, of Philadelphia, read before the American Institute of Mining Engineers, in September, 1896, at Colorado. This was the state of affairs in the autumn of 1896 when Mr. Percy C. Gilchrist and Mr. W. Panton, of Middlesborough, and a few days later Messrs. Alfred Darby and Peter Williams, of Brymbo, visited Kladno.

On this occasion two questions were proposed to us, viz.:

1. By Mr. Gilchrist: May the process be worked to advantage with 100 per cent. or nearly 100 per cent. of siliceous and phosphoric pig iron? and if so, with what results regarding the loss respectively, with what gain of metallic iron from the ore?

2. By Messrs. Darby and Williams: What proportion of highly phosphoric (basi c) pig iron may be worked with good results?

Based upon these questions a number of heats were made, the actual results of which I may consider generally known through the tables contained in the paper read by Mr. Gilchrist before the Cleveland Institute of Engineers in December, 1896. I must, however, remark here, that these heats were all more or less of an experimental nature, owing to the fact that neither furnaces nor men were at that moment prepared for work of this kind.

As already indicated, the open hearth furnaces at Kladno are regularly worked with pig iron and the scrap naturally resulting in the steel works and rolling mills. When working with a larger proportion of scrap, the furnace hearths need not be kept so deep, i. e., they may have less cubic capacity for a given weight of the heat than when working with pig iron alone, where a far greater quantity of additions of lime and ore are necessary for the elimination of the silicon and phosphorus, and the neutralization of the resulting slags.

The excessively lively boiling of such heats also necessitates a much greater depth of the hearths. The furnace hearths were, therefore, at that moment not of sufficient depth, i. e., not in the proper shape for charging the furnaces to their full capacity when making heats with a high percentage of phosphoric and siliceous pig iron.

This, together with the circumstance that the men at the furnaces were not perfectly drilled for work of this kind, naturally gave this series of heats an experimental character.

I must call special attention to these facts, since I understand that the work then done has met with unfavorable criticism, especially regarding the output and the weight of the heats made.

There can be no doubt that with furnaces properly arranged for the purpose, and with men already drilled for the work, much better results might have been obtained.

Following the question of working alone with the phosphoric and siliceous pig iron, especially with the intention of utilizing the reductive power of the carbon, phosphorus and silicon contained in the pig iron for an increase of the yield of metal from the iron contained in the ore, a series of experimental heats were subsequently made by charging gray forge pig containing about 3·8 per cent. of carbon, 1·0 per cent. of manganese, 1·6 per cent. of phosphorus, and 1·0 per cent. of silicon into the primary furnace, adding, besides the lime, larger quantities of magnetic Gellivara ore, with about 65 per cent. of iron.

The finishing furnace was here actually used only for finishing the heat. It was practically left empty, and only charged with a small quantity of scrap merely in order to have something in the furnace when heating it up to receive the heat from the primary furnace, then adding at the proper moment the necessary additions of lime, ore, and finally ferro-manganese for finishing the metal.

In the test twelve tons of forge pig iron were charged into the primary furnace. Since the heats boiled up excessively, repeatedly causing large quantities of slag to flow out of the furnace doors, a small quantity of pig iron was replaced by scrap in the subsequent heats, which helped to quiet down the metal. The sample ingot from the primary furnace was taken when the metal was tapped and flowed down into the finishing surface.

The work done by the primary furnace may be illustrated by comparing the average chemical composition of the pig iron with that of the sample ingots from the primary furnace, as follows :

	C.	P.	Si.	Mn.	
Pig iron	3·8	1·6	1·0	1·0	Together 7·4 p. c.
Ingot from primary furnace	2·2	0·4	0·05	0·05	....

Hence it follows that the silicon and manganese are practically fully eliminated in the primary furnace, while nearly two-thirds of the carbon and only one-fourth of the phosphorus are left in the metal for finishing in the lower furnace, a fact directly opposed to the results of basic Bessemer practice where the carbon is oxidized long before the phosphorus. This oxidation of the phosphorus in primary furnace before the carbon is highly important, since it greatly facilitates the work in the finishing furnace, inasmuch as only so much lime need be added in the finishing furnace as is necessary to perfectly neutralize the phosphoric anhydride resulting from the rest of the phosphorus, and it is, therefore, very easy to make the finishing slag highly basic, and thus insure a low percentage of phosphorus in the finished metal. In fact, the whole work in the primary furnace may be regulated by the amount of phosphorus to be left in the metal when tapping it into the finishing furnace.

At Kladno the finishing furnace is unfortunately situated too far from the primary one, so that the runner leading from one furnace to the other is long and of insufficient incline. It is therefore not feasible to run the carbon and phosphorus in the metal down still lower in the primary furnace, because such a metal, if not excessively hot, will not flow down a long runner of insufficient pitch. As regards the temperature of the heat, this to a great extent depends upon the silicon in the pig iron, whose oxidation helps to give the heat the proper temperature. A certain percentage of silicon is therefore favorable for the process, since its oxidation helps to heat the bath to the necessary temperature, and its further acting as a reducing agent upon the ore added helps to increase the yield of metallic iron.

Regarding the yield, it cannot be overlooked that there is in this series of heats excessively variable heat —No. 87,102 resulting in an actual loss of 0·3 ton = 2·36 per cent., while heat No. 87,072 shows an actual gain of 0·75 ton = 6·23 per cent. It must, however, be taken into consideration that the pig iron used contains together 7·4 per cent. of carbon, phosphorus, silicon, and manganese that are consumed by oxidation, so that even a loss of 2·3 per cent. represents a gain of 5·1 per cent. of metallic iron from the ore charged; while, on the other hand, a gain of over 6 per cent. of steel really means over 13 per cent. or one and one-half tons of metal gained from the ore.

The great variation in the yield must further be accounted for by the circumstance that in order to make these experimental heats it was necessary to leave the finishing furnace empty for more than half the time, and then to heat it up when wanted to the proper temperature. This must naturally cause irregularities that may influence the yield more or less favorably, as the case may be. These irregularities would of course be obviated by a perfect plan of two primary furnaces working alternately into one finishing furnace, so that the latter would be perfectly occupied and kept in regular, uninterrupted operation.

The shortcomings of the plant must therefore be taken into consideration when judging the results, and we must so far be contented with the proof that a yield of more than 100 of steel from 100 of pig iron charged may be reached when working with siliceous and phosphoric pig alone, a finished product of excellent quality being produced from it.

Regarding the time needed for the heats, the table shows that at the commencement a heat lasted about five hours in the primary furnace, which was decreased to 4½ hours to 4¾ hours as the men got accustomed to the work; in the same way the time in the finishing furnace was gradually decreased to about 2 hours to 2¼ hours. These figures show that one finishing furnace will certainly serve for two primary furnaces, the

* A paper read before the Iron and Steel Institute, May, 1897, and published in Industries and Iron.

more so as it is perfectly in the hands of the operator to regulate his work, and to determine the proper point of oxidation, and the lowest limit to which he wants to reduce the phosphorus in the primary furnace before tapping, i. e., to fix the most favorable way of dividing the work between the primary and the finishing furnaces. The time of the primary furnace will therefore determine the number of heats that may be made in twenty-four hours by a plant consisting of two primary furnaces and one finishing furnace.

Accepting the time of 4½ hours for a 12 ton heat in the primary furnace, and taking the time for charging and fettling into account, it is seen that two primaries will make at least nine heats in twenty-four hours. There is, however, reason to believe that with a properly arranged plant, with men once drilled for the work, nine heats of fifteen tons may be made in twenty-four hours. These figures, of course, refer only to the working of siliceous and phosphoric pig iron as given in the above description. How much the output may be increased when liquid pig iron coming directly from the blast furnace is charged into the primary furnace still remains to be determined by actual experiment.

There can, however, be no doubt that a very material increase of output must result in that case, together with a saving of labor for charging.

The analysis of the finished steel, as also the mechanical tests, prove a fair quality.

Silicon was not determined in the finished steel, since in the presence of so highly basic slags a more than nominal percentage of silicon is quite out of the question.

Sulphur was only determined in the finished steel, to prove that no sulphur had been absorbed by the metal in the course of the process, which might be the case when sulphurous ores are used. The sulphur in the pig iron was no higher than 0·05 per cent.

The slags from the primary furnace show a high percentage of silica; thereby also proving that practically all the silicon is oxidized in the primary furnace. When working with pig iron still higher in phosphorus, a slag high in phosphoric anhydride similar to basic converter slag must result from the primary furnace, that may be used for fertilizing purposes. The great bulk of the slag naturally results from the primary furnace.

The slags from the finishing furnace are naturally lower in silica and phosphoric anhydride and higher in lime, so as to insure perfect dephosphorization of the metal.

The comparatively low percentage of iron contained in the slags also proves that a large proportion of the iron contained in the ore has been utilized and reduced to metallic iron.

LABOR INSURANCE IN GERMANY.

IN the evolution of the wages system, the next step to be taken has to do with the problem of labor insurance.

Under the old hand labor methods of industry, this was a matter which may be said, in a sense, to have taken care of itself. The economic relations between lords and tenants, small employers and their helpers, were largely of a personal and obligatory nature, but with the rise of the wages system this bond of personal obligation gradually weakened. Instead of having his old feudal claim upon the aristocracy, the laborer was left more and more to shift for himself. Paupers and the unemployed and those disabled from work by age or infirmity become a public rather than a private charge. Poor rates were established, and the church came to inherit a large share of responsibility for maintenance of the poor. With the advent of the factory system and the attainment of religious liberty, the reliance of the laborer was transferred almost wholly to his wages. No obligation then rested upon any of the upper classes to look after his welfare. His nominal independence had been secured, but in the event of losing employment he was left economically helpless.

The gain of the laboring class in rising out of the hand labor regimé into the wages system was immense. The development of the capitalist and wages method of industry has meant a tenfold increase in the comforts of life, lessening of individual toil and ever widening social freedom and opportunities for the masses. At the same time this lack of provision for maintenance during disability and old age still remains the great defect of the wages system. The remedy needed is a scientific and comprehensive plan of labor insurance, incorporated into the wages system itself as an essential part of it and free from any suspicion of organized benevolence or enforced charity.

The necessity of this step has not yet been generally comprehended by capitalists in this country, nor has such a plan yet been made a part of our constructive statesmanship. Some American railroad companies and other corporations accord voluntary pension relief to a limited extent, mostly in the nature of special grants, but this is all.

Such is not the case, however, in Europe. Germany, Austria Hungary, Italy, Denmark and Switzerland all have more or less comprehensive systems of age and invalidity insurance, while a strong agitation in the same direction is in progress in several other countries. This is, of course, to be attributed more to the aggravated social conditions which have forced the question to the front than to any special recognition of the economics of labor insurance on the part of European statesmen. In Germany, at least, it came largely as a self-defensive measure on the part of the government. There is certainly no reason, however, why we in this country should also wait to be forced into this reform by absolute necessity.

The German system is, perhaps, the most comprehensive, certainly the most centralized of any yet developed. It has not been found to work to perfection, owing to its strongly paternalistic spirit, but at the same time it constitutes an important illustration of the practicability of labor insurance on a national scale. Its defects will at least serve as indications of what must be avoided in framing an ideal system.

A complete history and description of the German system is to be found in the Fourth Special Report of the Commissioner of Labor on "Compulsory Insurance." This report is the work of Mr. John Graham Brooks, who investigated the subject on the ground; it was prepared under the direction of Labor Commissioner Carroll D. Wright, and is thoroughly comprehensive.

Mr. Brooks carefully traces the origin and development of labor insurance from the customs voluntarily observed in the early German guilds and mining communities down to the imperial legislation of 1883, 1884 and 1889. Naturally, the influence of Manchester liberalism was against the whole proposition from the start. In 1876 these doctrinaires even secured a relaxation of the limited compulsion applied to employers by a law enacted in 1854. "Larger freedom will bring slower results, but safer ones," it was urged. In reality, "larger freedom" brought one result very promptly, i. e., a rapid decline in the progress of the whole insurance movement. But meanwhile a new school of economic thought had been gaining a foothold in Germany. The socialist party also grew at an alarming rate, and in 1878 two attacks were made upon the Emperor's life. From that time on the imperial policy of compulsory relief for the masses was forced through, theory or no theory. In 1883 the sickness insurance law was passed through the efforts of Bismarck, the Iron Chancellor, vigorously backed by the Emperor himself.

Under this law, all persons receiving less than $476 yearly wages, with a few special exemptions, are compelled to join some one of the various sick associations through which the machinery of the law operates. The insurance fund is maintained, two-thirds by the employe and one-third by the employer, but the total contributions must in no case exceed 4½ per cent. of the wages paid. The average contribution by work people is stated to be between 1 and 3 per cent. The minimum aid given consists of free medical attendance and medicine, and after the third day 50 per cent. of average wages for at least thirteen weeks. Certain of the associations grant extra relief in special cases. In 1891 the total expenditures under this department amounted to $21,312,610.

The accident insurance law, approved July 6, 1884, provides for a fund to be maintained by employers only, and the relief granted depends upon the nature of the accident. The injured person, however, is cared for first by the sick society, and is entitled to assistance from the accident fund only after the thirteen weeks have expired, unless the accident is wholly the employer's fault. In the latter case, the sick association may recover by law from the employer all that it has paid out for the injured man. Boards of arbitration, whose officers are appointed by the government, settle all disputes as to liability.

The old age and invalidity pension law was approved June 22, 1889. This fund is maintained jointly by the government, the employer and employes. The two latter make equal contributions sufficient to cover certain fixed expenses, the government's share being the same in all cases—$11.90 annually to each actual pensioner. After 1896 five years' contributions must have been paid into the fund before an invalidity pension can be claimed; between 1891 and 1896 only one year's contribution need have been made, provided the applicant has been regularly at work during the four years previous. For old age pensions the time of contribution is thirty years, except that in order to put the system into practical operation at once, all persons of seventy or over might receive pensions after January 1, 1891. The contributions are made by means of stamps purchased at the post office, and pensions are paid through the same agency. According to the Labor Gazette (London), the total amount thus expended in 1894 was £1,732,381 to about 230,000 pensioners for old age and invalidity. The government's contribution amounted to £692,744.

The Gazette's figures also show that the total number of persons insured under the old age and invalidity law, in 1894, was about 11,510,000; under the accident law, 18,191,747; and under the sick fund, for 1893, 7,232,854.

The chief criticisms to be made upon the German plan relate to the opportunities for fraud in the accident and sickness funds, and the bad effect of state contribution to old age pensions. Mr. Brooks finds the simulation of injury and sickness, especially "rheumatism," to be a most serious evil, and a growing one. The socialist organs have insisted all along that this fund belongs to the laborers by natural right, and practically encourage them to draw from it by all possible means. The effect is demoralizing in the extreme, and almost no remedies have been found. The tendency of state contributions to the old age pensions is to make employers transfer their old employes to the pension list as rapidly as possible, thus letting the public pay part of their wages, as was done in a little different way under the old English poor law.

In the system to be developed in this country, employers ought to stand the whole expense of labor insurance. This would be equivalent to a wage increase of only two or three per cent., and, being equally borne by all, could be no real burden to any. If it proved a handicap in meeting foreign competition, the remedy would be that urged by Bismarck in defending the German insurance scheme, namely, a higher protective tariff.

The German experiment furnishes an object lesson, both in what to avoid and what to imitate. It is the part of good statesmanship, in this country, to take up the labor insurance problem now, and get the benefit of the experiments made by others, without having to repeat their mistakes.—Gunton's Magazine.

THE THEORY OF DREAMS.

UNDER this heading Dr. L. Menard explains to us in Cosmos, says the Literary Digest, some of the most curious psychological phenomena of dreams, and relates some of the most celebrated dreams, giving each its scientific explanation. He says:

"In sleep the superior centers of personal and conscious activity are at rest, while the inferior or so-called automatic centers are awake; but these latter keep up more or less intimate relations with their chiefs, and also with the outer surface of the body.

"The relations with the outer surface explain how sensations experienced during sleep may give rise to dreams; they explain, also, how a more or less vivid or unaccustomed sensation, according as the sleep is more or less deep, may awaken the sleeper.

"If communications are kept up with the superior centers, the subject retains a recollection of his dream—a recollection more or less vague and more or less durable. He can, also, when these communications are quite complete, influence his own dream—understand, for example, that such and such a sensation is the effect of a dream, and wake himself in order to stop it.

"Certain dreams, of which we retain no immediate recollection, are nevertheless impressed on the memory. Thus recollection of them takes place in another dream or in states of somnambulism.

"When we are preoccupied with some problem, it may happen that we lay it aside for the moment, and that after a longer or shorter time, when we believe that we are no longer thinking of it, the solution appears to us suddenly, like a flash of light. We have kept on thinking of it without knowing it. This work of unconscious cerebration keeps on during sleep, and if a sought for solution comes to us in a dream, it is but the product of this brain work, pursued unconsciously.

"Which of us has not noticed that he remembers better a thing that he has studied in the evening just before going to sleep? Voltaire tells us that one night he dreamed a complete canto of his 'Henriade,' which fact inspired the following reflection:

"'I said in my dream things that I could scarcely have written in my waking hours; I must then have had processes of thought, in spite of myself and without conscious action; I had neither will power nor freedom, and yet I made combinations of ideas with sagacity and even with some degree of genius.'

"It was the automatic centers that were at work in this case, but these centers had kept up communication with their hierarchical superiors, and the recollection of their action had remained with him.

"The most various combinations can be produced, according as the communications with the outer world or the inner self are more or less complete. We may mistake the reality for a dream, and vice versa. Reil tells of a person who dreamed about what was whispered in his ear while he was asleep.

"Once when I was in the country, sleeping in a room that had not been occupied for several years, I dreamed that I saw a mouse run over the bed, and that I killed it. Sure enough, in the morning there was the dead mouse at the foot of the bed. I had acted in a sort of somnambulism.

"At other times the contrary takes place, and we are in danger of mistaking a dream for the reality. Except in illness, this illusion is of brief duration, and takes place only at the moment of waking.

"Dreams engendered by sensations of pain often herald approaching illness, and seem prophetic. Conrad Gesner had a dream in which he saw a serpent bite him on the left side of his breast. A deep and profound lesion soon appeared in that part of his body. Galien tells of an invalid who dreamed that his leg was made of stone; some time afterward, this leg was paralyzed. Macario relates that he dreamed that he was suffering from a severe sore throat; when he awoke he was perfectly well, but several hours afterward he had an attack of quinsy.

"In these examples, which could be easily multiplied, there was a clearer perception of real sensations during sleep than in the waking state. Galien's invalid perceived more clearly during the night the beginning of a functional derangement that ended in paralysis. Conrad Gesner had a pain in his side, and it was not until later that this pain was explained by the appearance of an actual lesion.

"The automatic centers sometimes present to us an interlocutor who solves the problem on which we are working. . . . Thus the following dream of Dr. Alexander Bertrand:

"'He saw before him a person who asked him questions about the etymology of several French words. After several questions that M. Bertrand does not recollect, he propounded the following: "Do you know what the word dame [lady] comes from?" M. Bertrand, after a moment of reflection, answered that he did not know. "Think carefully," went on the speaker. "Perhaps from the word domina?" said M. Bertrand. "Wrong! guess again;" and during this colloquy the stranger had the manner of a man who, being sure of himself, amuses himself with the embarrassment of another. Bertrand finally giving up the task, the other said to him with a laugh: "Don't you see that the word comes from damnatio?" And this pleasantry, quite opposed to M. Bertrand's serious character, surprised him very much. His astonishment was increased when he woke and, realized that this comedy was a dream, and that he alone had done the joking.'

"A celebrated dream where a curious and fantastic scene accompanied the unconscious intellectual labor of the dreamer was that of Tartini. This celebrated composer had gone to sleep after having in vain tried to finish a sonata; this occupation followed him in his sleep. At the moment when, in a dream, he thought that he had resumed his work and that he despaired of being able to compose what he wished, he saw the devil, all of a sudden, appear and offer to finish his sonata if he would give up his soul. Quite subjugated by this apparition, he accepts the proposed terms, and he then hears very distinctly played on the violin the much desired sonata, with inexpressible charm of execution. He awakes, and in a transport of joy runs to his desk and writes down from memory the piece that he had just dreamed.

"Tartini's intellectual work had been carried on while he slept, and the mental image of the devil was a mere complication of his dream, owing to an association of ideas, probably related to something that he had recently been reading.

"Sometimes the dream simply evokes a forgotten image from the depths of the memory. Abercrombie relates that a bank employe found on balancing his account that he was short by 6,000 francs. After vainly seeking to find his mistake, he went sound asleep and saw in a dream a man who demanded to be paid at once, as he could not wait. He recollected, in fact, that some time before he had paid out this sum and had forgotten to enter the payment. A similar dream was related by Dr. Liebault; it is told by Marie de Manaceine as follows: 'One of his patients dreamed that she was in danger of drowning, when she was saved by a man named Olry. Several years passed; suddenly there entered her house a gentleman who resembled in every feature the one who had saved her in her dream. She was so powerfully impressed by this resemblance that she at once cried out to her visitor: "You are Olry?" "Yes, my name is Olry," answered this stranger, whom she had never seen except in her dream.' M. Liebault remarks that such a dream might very well be looked upon as miraculous, but a careful

inquiry showed that this Olry lived in the vicinity, that is not more than 12 kilometers [7½ miles] distant; she had probably met him before, but apparently she had forgotten the fact, as well as the family name of her imaginary savior.

"In such a case that which is produced is the recollection of the images impressed on the consciousness.

"As we have said before, the dreamer creates nothing; he utilizes the images that he has previously stored up."

FULLER'S EARTH.

THE term "fuller's earth" is used to include a variety of claylike substances which have absorbent properties. Judging from the analyses made, the composition of fuller's earth varies considerably, although this may be due in part to impurities, and indicates that all fuller's earth does not contain a high percentage of combined water, as most books state, nor a large amount of magnesia, as claimed by some. The high percentage of combined water seems to be true of most of the foreign occurrences.

Fuller's earth is generally fine grain, but non-plastic, thereby differing from true clay, and when thrown into water and broken up forms a somewhat flocculent mass. Even when simply air dried it adheres strongly to the tongue.

Fuller's earth was originally used for cleansing cloth of grease, and also for cleansing furs. In the latter case the fur was covered with a considerable quantity of the earth and rubbed or trodden. It has also been used as an absorbent by druggists. At the present day its chief use is for clarifying oils.

In clarifying lard oil the fuller's earth ground to 120 mesh is added to the hot oil and stirred for a short period; the oil is then passed through a filter press, the earth and coloring impurities being left behind. The degree of fineness of the fuller's earth is of great importance, and it is necessary to heat it well before use.

In clarifying lubricating and similar oils the fuller's earth is now being used as a substitute for boneblack. In this case it does not seem necessary to grind the material so fine.

Fuller's earth occurs in Saxony as the result of decomposition of diabase and gabbro. In England it forms a bed 150 feet thick in the Lower Oolite of the Jurassic. The material forms an argillaceous deposit extending from Dorsetshire to Bath and Cheltenham.

The development of fuller's earth in the United States is of comparatively recent date and has occurred in Florida, Georgia, Virginia, and South Dakota. Fuller's earth was discovered at Quincy, in the northwestern part of Florida, about one and one-half years ago, and its development caused so much excitement that persons all over the State have been searching for the material, with the result of finding much of it, but of variable quality. In the northwestern part of the State, in Gadsden county, fuller's earth has been found around Quincy, Mount Pleasant, Norway and River Junction.

After mining, the usual method is to spread the material in a thin layer over a drying floor constructed of planks. It is thus dried in the sun, and in drying it bleaches to a white color. The material is then gathered into sacks for shipment. By this method about 60 per cent. of moisture is removed. Certain companies dry a large portion of their output in cylinder driers heated by a strong fire. The material passes through these in about four minutes. It is first ground, however.—The Registered Pharmacist.

INFLUENCE OF INTELLECTUAL WORK ON BLOOD PRESSURE.

THE influence of intellectual work on the blood pressure in man is the subject of a paper, by MM. A. Binet and N. Vaschide, in a recent number of the Psychological Review. The instrument used by the authors was Mosso's sphygmomanometer, which has the advantage of indicating the results by tracings. The method of experimentation consisted in taking the pulse under increasing pressure from 0 to 140 mm. of mercury; this test was made at first while the subject was in a state of rest, without excitement or preoccupation of any kind; then the same experiment was repeated while the subject was absorbed in a difficult mental calculation. Two tracings were thus obtained for comparison, and the differences between them could be attributed to the intellectual labor, unless some chance circumstance—as an emotion, a shiver, etc.—prevented the two experiments from being strictly comparable. From the results obtained, it appears that the maximum amplitude of the pulsation tracings was greater during rest than during intellectual work. It was 5 mm. in the former case and only 3·5 mm. in the latter. During all the mental calculations there was evidently a diminution of the pulse, as the result of a more or less marked vascular constriction. In both states the maximum amplitude of the pulse appears to have been reached when the blood pressure was 80 mm. Beyond this pressure, the amplitude decreased more rapidly during the state of rest than during mental activity, and a pressure of from 100 to 120 mm. was found to completely suppress the pulsation both in a state of repose and in a state of intellectual labor. To determine the difference between the circulation in a state of intellectual labor and that of rest, a counter pressure of 110 mm. was chosen. A register of the pulse with this pressure was made for about half a minute, and then the subject was told to commence a mental calculation. The first three or four pulsations after he was told to begin were of the same character as the preceding ones, but afterward the pulsations became twice and, often, three times as great. This increase in amplitude maintained itself, in general, without increase or diminution, and with great regularity during the whole of the mental calculation. When the problem had been solved, the pulsation gradually diminished, and finally reached the original condition.

The percentage loss of light from various illuminants in passing artificial fog solution is as follows:

Coal gas flames	11·1
Sunlight mantle	18·3
Acetylene flames	14·7
Welsbach mantle	20·8

TABLE OF CONTENTS.